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A Comparison of Tillage Implements Based on Research Results *R. L. Cook and F. W. Peikert*

Liquid Petroleum Gases as Fuels for Farm Power Units *George H. Larson*

Results of Studies of Cotton Mechanization in California *J. P. Fairbank and K. O. Smith*

Designing Hay Driers for the Use of Supplemental Heat *R. B. Davis, G. E. Barlow, D. P. Brown*

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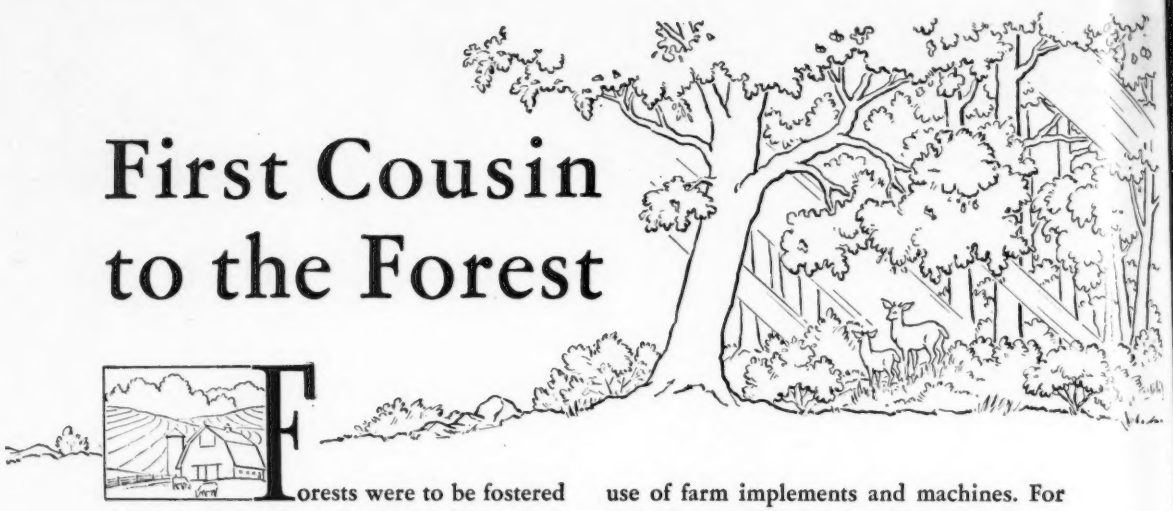

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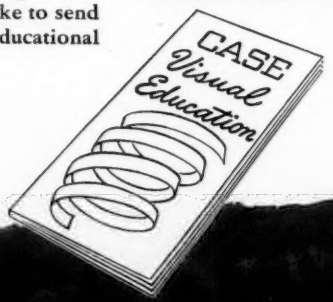

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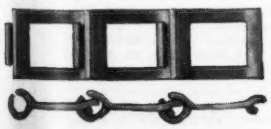

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EDITORIAL

Our Stake in ASAE

A Message to Agricultural Engineers:

IN UNDERTAKING to evaluate membership in the American Society of Agricultural Engineers, let us first briefly consider the background of the Society. Like all professional societies, ASAE had a modest beginning. A few enthusiastic and far-seeing engineers founded the organization and nurtured it during the early years. Soon others came in and aided in developing its activities. Certainly no one would question that the efforts of all those who launched and who have supported the organization all these years, have laid the groundwork for recognition of the agricultural engineering profession As the organization grew in size and gained stability, it gradually exerted more and more influence in its efforts to obtain wider recognition for its members and in its efforts to be of greater service to the agricultural industry.

Is there among us today any who are so shortsighted as to suppose that all of us are not in a more favorable position as agricultural engineers as a result of the activities of ASAE. I doubt it. More people know of agricultural engineering and the broad field of service it offers to society; new avenues of employment have opened up; in many areas a large demand has been developed for agricultural engineering services, and the prestige of agricultural engineering as a profession has been greatly enhanced. Is it reasonable to suppose that so much progress could have been made by agricultural engineers working independently without an over-all coordinating professional society? Of course not; the impossibility of such an achievement is obvious. The old saying that "in unity there is strength" is still a fundamental truth.

Now, if we can agree with the foregoing, and on the basis of an honest and sincere appraisal of the facts we can, should we not critically examine the question sometimes raised, of whether or not it is too expensive to affiliate with ASAE. In the first place, is it not farfetched to presume that we could measure the value of professional society membership in dollars and cents? Rather should we not look at the achievements of the Society, the achievements of a group of agricultural engineers banded together in a unified working organization, if you please, in advancing the total interest of agricultural engineers and the agricultural industry? It is doubtful that even in our most thoughtful moments we could hazard a reasonable estimate of the value of these efforts. But nevertheless each of us individually, after giving some thought to the matter, cannot escape the conclusion that benefits do and will continue to accrue to us.

Should we not in some measure try to evaluate the prestige of agricultural engineering in general and the prestige of our own individual positions and our opportunities for real service to society on the basis of what ASAE through its membership, has done to put agricultural engineering on the high level of public approval to which it has attained? If we can but do this objectively, can we reach any conclusion other than that all of us, whether members of ASAE or not, have benefited? It is doubtful that we can evolve an answer based on monetary standards, but the fact that we have benefited is inescapable. Of how much value has this been to all of us?

Assuming that we agree that all of us have benefited through the activities of the Society and the efforts of its members, does it not appear that individually and collectively we may expect to benefit even more in the future if more of us align ourselves with our professional society and thereby lend our support to its aims and objectives, one of which is to enhance the status of the engineer in agricultural engineering work? Should we not appraise the accomplishments of the past in terms of greater prestige, greater appreciation of agricultural engineering activity, and greater service to society? And then, if our honest appraisal of the facts shows us that the results have been good, is it not a matter of good judgment, if for no other reason than intelligent self-interest, that we all, as agricultural engineers, align ourselves with our professional society in order that we may more effectively promote the interest of agricultural engineering and agricultural engineers everywhere.

Would it not be well to remember that "In unity there is strength?"

UNUS F. EARP

Registration Is Important to You

NO MATTER where you reside, where you work, or what phase of engineering you engage in, you may find it increasingly difficult, as time goes by, to convince the public that you are "a professional engineer" unless you are duly registered.

That is a strong statement. It may possibly make you downright mad. But before you get too steamed up, let's back off a ways and see what is happening to ths status of the engineer — the professional engineer.

The practice of the profession of engineering is receiving marked scrutiny from the public. Every state and many of the territories have registration laws requiring the registration of professional engineers in one form or another. The adoption of these laws began with the passing of the Wyoming law in 1907. The fact that they have now spread so widely is proof that they are not merely a passing fancy that will pass by and fade out.

The requirements forregistration as a professional engineer are reasonable. In most cases, the standards are same as those required for a baccalaureate degree from an accredited engineering college with subsequent satisfactory professional engineering experience.

If you are qualified, any argument as to why you are not registered is a weak one at best. Even though your position is such that you are not required to be registered (many agricultural engineers are in work specifically exempt under registration laws) the fact remains that the public is cognizant of professional engineering and expects all engineers to be registered.

Our younger engineers particularly are going to feel increasing pressure for registration in all phases of engineering.

Whether ye like it or not, the "professional stature" of an engineer is going to be severely handicapped unless he is registered.

If you haven't inquired into registration in your state, do so now. Find out what the requirements are. You can get information from your state capitol.

Registration is important to the whole profession of engineering. It is important to agricultural engineering. It is important to YOU.

B. F. MUIRHEID

Farm Machine Use Economics

A RECENT report on "Cost of Operating Farm Machinery" under conditions common to eastern Canada covers a number of interesting points and suggests others which may warrant more detailed consideration.

The report covers studies on 50, 100, and 200-acre farms, with 70 to 90 per cent of the acreage under cultivation. Indicated investments in power units and operated equipment for both field and barnyard operations range from about $25 to $80 per acre.

Annual costs of the equipment range from 14 to 26 per cent of the amount invested, depending to some extent on the nature of major items and the character of service required.

Under more intensive farming considerably higher investments per acre may be justified. More general appreciation of the annual cost would lead to more accurate evaluation of this one factor influencing optimum investment.

Total annual machine cost per acre, for combinations of 10 to 25 operations variously practiced on the farms studied, ranged from $6.45 to $17.50. This *(Continued on page 214)*

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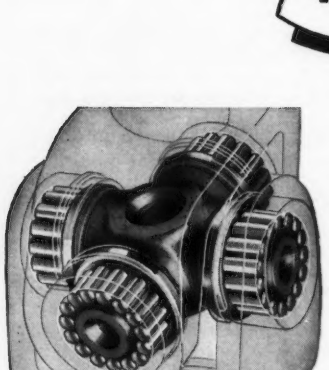

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AGRICULTURAL ENGINEERING

VOL. 31 MAY, 1950 No. 5

A Comparison of Tillage Implements

By R. L. Cook and F. W. Peikert

MEMBER A.S.A.E.

ROTARY tillage has attracted a good deal of attention during the past few years. Interest in this kind of tillage, where the vegetation is mixed with the surface soil, has been strengthened by the realization of its value in the control of soil erosion. Further interest in rotary tillage has resulted from claims that seedbeds may be prepared in one operation, thus effecting great savings in time and expense.

The introduction, since the war, of several new rotary tillage machines has led to questions regarding the relative merits of the different kinds of soil preparation made possible by these machines.

The change from horse to tractor power has resulted in more soil fitting and in many cases in excessive packing of the soil. Excessive packing occurs particularly where heavy soils are worked while the moisture content is high and during harvesting operations in rainy seasons.

Experiments in which rotary methods of tillage have been compared with the conventional, as well as with several other methods, were conducted over a period of four years. The tests were run with a variety of crops on heavy and light soils. The results are presented in this paper.

Machines. Three of the machines included in these tests mixed the vegetation with the disturbed soil. The rotary-type tiller was a walking, two-wheel machine with flexible tines. Where there was little or no vegetation, the soil was prepared by going over the land once with hook tines to a depth of 6 in. Considerable vegetation, however, made it necessary to use knife tines, then follow with hook tines. It was not possible to secure the 6-in penetration with the knife tines.

Since the experimental plans called for planting immediately after tillage, the soil was packed after tillage with the rotary tiller.

The auger-type plow is simply a spiral auger driven from the tractor power take-off. The power requirement of this machine was so high that it was only possible to cut a 20-in strip with a two-plow tractor.

A third machine which mixed the vegetation with the surface soil was the vertical-disk plow. This machine consists of five disks which turn as a unit. It was set to cut a strip about 44 in wide and 6 in deep. It was then generally necessary to work the soil twice with a disk harrow and twice with a spring-tooth harrow. Sometimes more than two diskings were required.

Tillage Involving Moldboard Plows. One of the tillage treatments involved the use of a plow with sub-bases. The standard bottoms were set at 6 in. Below these are two sub-bases which run in the furrows turned by the upper bottoms and which were set to cut an additional 3-in depth, thereby mixing part of this lower soil with the top layer.

The control treatment in these tests was that in which the soil was plowed with a conventional plow to a depth of 6 in and was then worked twice with a double disk harrow and twice with a spring-tooth harrow. The disking was generally omitted for oats. In the three treatments—vertical-disk plow, sub-base plow, and conventional plow—the tillage with disk and spring-tooth harrow was uniform.

Two "once-over" tillage operations were accomplished by attaching to a conventional plow the two tillage units shown in Figs. 1 and 2. The plow-packer consists of a series of cast wheels which run loose on a steel shaft. A steel frame made it possible to add extra weight for more efficient packing.

The mulcher (Fig. 2) consists of a double soil packer with a group of spring teeth between the packers, all within a single frame. It was attached to trail beside the plow. After the mulcher and plow-packer, the crops were planted without further tillage. In fact, in 1948 a seeding unit was attached to the packer so that the oats were drilled in the same operation with the plowing. The entire unit was pulled with a two-plow tractor.

SOILS AND CROPS

Heavy Soils. One set of tests was on Brookston clay loam in Tuscola County, Michigan. The work was started in 1946 on land which had been well farmed for many years and was in good physical condition. Corn had been grown in 1945. Four different crops were grown each year. During 1947 and

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Power and Machinery Division. This paper is also a contribution from the soil science and agricultural engineering sections, Michigan Agricultural Experiment Station, and is authorized for publication by the Director as Journal Article No. 1133 of that station.

The authors: R. L. COOK and F. W. PEIKERT, respectively, professor of soil science and former professor of agricultural engineering, Michigan State College, East Lansing.

Fig. 1 (*Left*) Two-bottom conventional moldboard plow, with plow-packer attached, pulled by two-plow tractor • Fig. 2 (*Right*) Two-bottom conventional moldboard plow, with mulcher attached, pulled by two-plow tractor

1948, corn, sugar beets, oats seeded to sweet clover to be plowed under the following spring, and beans were rotated in the order named.

In 1949 a similar experiment was conducted on a Brookston loam soil. Tillage with the auger-type plow was omitted. In this instance corn, sugar beets, and beans were planted where oats had been grown in 1948.

Sandy Soil. Another set of tests has been conducted for the past three years on Hillsdale sandy loam on the Michigan State College farm near East Lansing. In 1947 beans and corn were planted on a heavy brome grass sod. In 1948 beans followed corn and oats were planted after beans. Corn was again planted on heavy brome grass sod.

By 1949 the rotation had been established so that corn followed alfalfa which had been seeded in the summer of 1947, beans followed corn, and oats followed beans. The 1949 oats yields are not included in this report.

RESULTS

Brookston Clay Loam. The data reported in Table 1 show that, on the clay loam soil in 1947 and 1948, conventional

TABLE 1. The Effect of Various Methods of Tillage on the Yields of Several Crops on Brookston Clay Loam in 1947 and 1948

Tillage method	Yield per acre (2 yr average)			
	Beets, tons	Oats, bu	Beans, bu	Corn, bu
Conventional plow	11.2	88.5	26.3	51.3
Plow with subbases	11.4	93.0	29.6	51.6
Plow with plow-packer	10.7	88.9	24.0	52.8
Rotary-type tiller	10.3	89.0	15.3	50.8
Vertical-disk plow	11.0	93.3	25.9	53.6
Auger-type plow	9.4	89.3	19.8	51.3
Difference required for significance	1.07	Not significant	8.4	Not significant

plowing and tillage resulted in yields as great as or greater than any of the yields obtained where other methods of tillage had been employed.

Oats and corn in this field followed cleanly cultivated crops where there was no vegetation to work into the soil. Under such conditions, as the data show, the two methods of rotary tillage resulted in yields fully as high as did the method of conventional tillage. The use of the vertical-disk plow resulted in slightly increased yields but the increases were not significant. In the case of sugar beets, however, where corn stover had to be worked into the soil, the average yield which resulted from the use of auger-type plow (9.42 tons per acre) was significantly less than where a moldboard plow was used. The yield obtained on the rotary-type tiller plots was also relatively low, 10.26 tons per acre compared with a yield of 11.20 tons from plots where the soil preparation was conventional.

Bean yields were also low where the soil was prepared with either of the rotary machines, probably because it was necessary to work into the soil a heavy growth of sweet clover. Even though the plots were covered two or three times with the machines, it was impossible to do a good job of seeding. Poor stands resulted. Perhaps if several days' time had elapsed between the first and second workings with the machines, better results might have been obtained. This was impossible, however, because plans called for planting some of the plots as soon as they were plowed and to make fair comparisons, all plots had to be planted on the same day.

It is of interest that the yields from plots where the plow-packer was used were about equal to those obtained from plots which received conventional tillage. In 1947 cultivating was done with a heavy tractor which so depressed the soil between the rows that some of the plants were destroyed. In 1948, the oats were planted when the soil was too wet for best results with the plow-packer. In fact, the packer did very little in the way of soil preparation for the press drill which followed. Even so, the yields were just about equal to those from the plots fitted in the conventional way.

Again in 1949 the plots which had been plowed and fitted in "once-over" operations, by use of the plow-packer and mulcher, produced yields of beets, beans, and corn as high as did those plots which were fitted in the conventional manner. This is shown by the data presented in Table 2. In fact, while

TABLE 2. The Effect of Various Methods of Tillage on the Yields of Several Crops on Brookston Loam in 1949

Tillage Method	Yield per acre, bu		
	Beets	Beans	Corn
Conventional plow	13.8	33.4	74.3
Plow with subbases	12.4	33.3	69.1
Plow with plow-packer	14.6	33.8	75.6
Rotary-type tiller	13.4	21.4	29.0
Vertical-disk plow	13.6	28.9	48.5
Plow with mulcher	15.9	30.7	61.8

the data were not statistically analyzed, the figures indicate that yields of sugar beets were actually higher where the soil had received only these "once-over" tillage operations. When one considers the time saved by such meager tillage, the advantage is easily apparent.

That rotary tillage resulted in good beet yields in 1949 is evident from the data shown in Table 2. Weeds were more plentiful, however, on the plots which had been so fitted, and had they not been early eliminated by hand-hoeing, the yields would have been depressed.

Corn and bean yields were much reduced in 1949 where the rotary-type tiller and the vertical-disk plow mixed the vegetation into the surface soil. It is believed that the reductions were largely the result of weed competition. This subject will be discussed later.

TABLE 3. Effect of Various Methods of Tillage on the Yields of Several Crops on Hillsdale Sandy Loam Soil

Tillage method	Yield per acre, bu						
	Corn			Beans			Oats
	1947	1948	1949	1947	1948	1949	1948
Conventional plow	40.9	25.7	45.5	11.8	8.2	24.8	53.2
Plow with subbases	44.2	20.4	46.2	11.4	7.5	25.2	51.0
Plow with plow-packer	44.6	32.5	44.9	13.4	6.7	23.6	53.8
Plow with mulcher	39.7	25.1	50.3	13.2	8.1	23.7	52.9
Rotary-type tiller	43.4	16.6	40.1	10.2	6.4	21.6	31.7
Vertical-disk plow	43.0	20.3	44.2	9.2	7.6	25.3	48.7
Auger-type plow	45.6	20.0	38.0	8.9	7.0	23.2	38.8

Hillsdale Sandy Loam. The experimental results reported in Table 3 were obtained on the College Farm where the soil is Hillsdale sandy loam. Corn and beans in 1947 were planted after brome grass. Where the grass was not turned under much hoeing was necessary to keep the plots clean. Records were kept of the time necessary to hoe each plot. These data are presented in Table 4 and will be discussed later.

TABLE 4. Relative Time Requirements for Hoeing Corn and Beans After the Various Methods of Tillage

Tillage methods	Relative time requirement, per cent	
	Corn	Beans
Conventional plow	100	100
Plow with subbases	100	124
Plow with plow-packer	113*	61
Plow with mulcher	74	95
Rotary-type tiller	174	188
Vertical-disk plow	171	210
Auger-type plow	145	195

* The plots where this treatment was used in 1947 were disked and harrowed after the plow packer so the treatment was actually similar to the conventional

Corn yields in 1947 were not greatly affected by the various methods of tillage. In fact, the highest yield was where the soil was prepared with the auger-type plow. The second highest yield was produced on plots where the plow-packer was used. In reality, however, this treatment in the 1947 corn experiment in this field was very similar to the conventional plow treatment because the plots were disked and har-

rowed after plowing. This was because the particular tractor available did not have sufficient power to make possible the desired weighting of the plow-packer. As a result, the seedbed was not satisfactory for planting without subsequent tillage.

In 1948 corn was again planted after brome grass. Where the sod was mixed with the worked layer of soil as with the rotary, auger, and vertical disk machines, yields were lowest. The comparatively low yield from the plots prepared by the subbase plow is not in accord with other results in this experiment and cannot be explained. Wherever the sod was turned under with the conventional plow, yields were considerably higher, with the best average yield obtained where the plow-packer followed the plow as a once-over operation and planting immediately followed.

It is interesting that in 1949, when corn followed alfalfa, the highest yield of corn occurred where the fitting was done with the mulcher following the plow. Yields were about the same following the other moldboard plow treatments and were again down where the vegetation was worked into the surface soil.

Bean yields in 1947, as shown in Table 2, seemed to fall into three groups. The highest yields were obtained on the plow-packer and mulcher plots, with the poorest results on those plots where the sod was mixed with the surface soil with the rotary and auger-type machines. The yields obtained where the conventional and subbase plows were used were intermediate. Perhaps these results indicate that the most desirable seedbeds are those where grass and weeds are well covered so they will not compete with the crop, but where the soil is not too firmly packed. This condition was obtained by the use of either the plow-packer or the mulcher. It is recognized that soils vary in their response to packing, but much evidence is accumulating that excessive packing is detrimental. It may be even more injurious on sandy loam

Fig. 3 (*Top, left*) Bean plot prepared with conventional plow and attached plow-packer (17 days after planting) • Fig. 4 (*Top, right*) Bean plot prepared with conventional plow and attached mulcher (17 days after planting) • Fig. 5 (*Center, left*) Bean plot prepared with conventional plow followed by normal tillage (17 days after planting) • Fig. 6 (*Center, right*) Bean plot prepared twice over with rotary-type tiller followed by soil packer (17 days after planting) • Fig. 7 (*Bottom, left*) Bean plot prepared with vertical-disk plow followed by normal tillage (17 days after planting) • Fig. 8 (*Bottom, right*) Bean plot prepared twice over with auger-type plow followed by soil packer (17 days after planting)

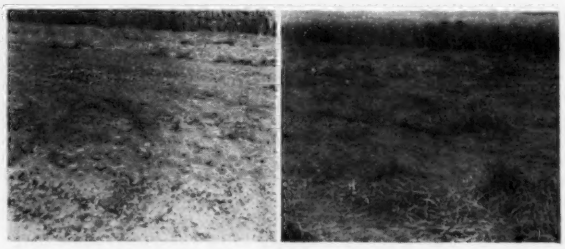

Fig. 9 (*Left*) Bean plot after the 1949 harvest. Tillage was conventional. Note freedom from weeds • Fig. 10 (*Right*) Bean plot after the 1949 harvest. Tillage was accomplished by going over the plot twice with a rotary-type tiller and once with a soil packer. Note piles of weeds.

than on clay loam soils, depending perhaps on the nature of the sandy loam and the moisture content of the soils at the time of working. Sandy loams do not contain sufficient clay to cause stable granulation, but some contain enough clay and very fine sand to fill the pores and slow up the movement of both air and water.

Owing to drought conditions which caused very poor yields of beans in 1948, no valid conclusions can be drawn from the results.

One very interesting observation, made during the 1949 season, was verified by the yield data. The plots which were listed as rotary-tilled plots were actually plowed with the conventional plow. This was because of mechanical difficulties encountered at the time it was necessary to plant the plots. Despite the plowing for the beans the plots still contained more weeds than did those plots which had been plowed in 1948 as well as in 1949. The yield data show that the so-called rotary-tilled plots did produce lower yields in 1949.

Effect of Tillage Methods on Weed Growth in Beans and Corn. Maximum yields of beans and corn cannot be expected unless weeds are controlled. In 1947 both of these crops were planted on the Hillsdale sandy loam after brome grass. Where the moldboard plows were used, the brome grass was turned completely under. The crops were then planted immediately. Where the planting was done after the plow-packer and mulcher, without subsequent disking or harrowing, grass competition was not severe, as shown by the data in Table 4 and Figs. 3 and 4. A little more serious competition occurred where the conventional plowing had been followed by normal tillage, as shown by Fig. 5.

MOLDBOARD PLOWS LESSENED GRASS COMPETITION

Where the rotary-type tiller, the vertical-disk plow, and the auger-type plow were used, grass competition was very severe as shown by Figs. 6, 7, and 8, and the time necessary for hoeing was much greater than where the moldboard plow was used. The relative time requirements for all the treatments are shown in Table 4.

In 1949, weeds again played a major role in bean yields. On the heavy soil the yield from plots worked with the rotary-type tiller was 21.4 bu per acre as compared to 33.4 bu from plots worked in the conventional manner. It is believed that much of the difference was due to weed competition. The weed growth is evidenced by pictures taken after the beans were harvested, Figs 9 and 10.

SUMMARY

Several types of tillage machines have been compared on three predominant Michigan soil types. Corn, sugar beets, oats, sweet clover, alfalfa, and beans have been grown. The machines used in the tests were as follows:

1 Conventional plow followed by normal tillage
2 Plow with subbases followed by normal tillage
3 Conventional plow with plow-packer attached, a once-over operation
4 Conventional plow with mulcher attached, a once-over operation
5 Rotary-type tiller followed by soil packing
6 Vertical-disk plow followed by normal tillage
7 Auger-type plow followed by soil packing.

The information obtained to date may be summarized as follows:

1 Under average soil condtions, where the surface was practically free of vegetation, the yields obtained following the various machines were about the same as those where conventional tillage was used

2 Where beans have followed sweet clover or brome grass the yields from soil prepared by the rotary-type tiller and the auger-type plow have been substantially lower than those obtained from other plots

3 Where crops followed sod, weed control was much easier where the sod was completely turned under than where it was mixed with the surface soil

4 The once-over soil preparation made possible by the plow-packer or mulcher attached directly to the conventional plow seems to offer good possibilities for decreasing cost of seedbed preparation while still maintaining yields comparable with those obtained by conventional methods.

Farm Machine Use Economics

(Continued from page 209)

is enough to suggest the desirability of further study on the cost of individual operations; the influence of equipment sizes, types, and manner and extent of use on equipment costs and other costs.

It is easy to see, for example, how faulty adjustment or operation of machines or breakdowns resulting in considerable idle labor, could add several dollars per acre to normal costs for any one year.

Influence of machines on productivity, the other factor influencing optimum investment, may involve an even wider dollar range.

Returns are not dealt with in the Canadian study. It seems apparent, however, that the difference in productivity resulting from a year of thoroughly sound, efficient operation, and that resulting from mediocre or poor operation, might be several times the amount of any reasonable annual equipment cost.

In other words, any close figuring of optimum farm operating efficiency would involve calculating optimum equipment investment per acre down toward some figure, plus or minus a few dollars, for an individual farm or operation. This figure might be definite for any one time, but it would be subject to change with conditions.

There will be little point in figuring costs per acre this closely, however, until the greater opportunity to increase net returns per acre through optimum productivity is well developed. It is easy to be penny-wise in limiting equipment investment. It is considerably more difficult to avoid being pound-foolish in overlooking opportunities to use equipment most effectively and to produce most efficiently. One of the big opportunities in agricultural engineering and in the farm equipment industry, it seems, may be the opportunity to further develop the principles of production engineering as they pertain to farming, and to help farmers apply them.

A Correction

THE attention of our readers is called to two corrections in the paper entitled "Evaluation of Factors Affecting the Operating Stability of Wheel Tractors", by Wayne H. Worthington in AGRICULTURAL ENGINEERING for March, 1949 (vol. 30, no. 3, pp. 119-123).

The last equation in the first column on page 122 should read as follows:

Instability moment, $M_1 = HP_1$
$= H(P - W \sin\beta)$

Equation [4] on page 123, as corrected, should read as follows:

$$P_1 = \frac{\mu W(L_2\cos\beta + H_{cg}\sin\beta) - W_B(W\sin\beta + R)}{W_B - \mu H}$$

LP Gas as a Fuel for Farm Power Units

By George H. Larson
MEMBER A.S.A.E.

LP GAS is comparatively a newcomer among engine fuels. LP gas is an abbreviated term for "liquified petroleum gases" which include butane (C_4H_{10}), propane (C_3H_8), or any mixture of the two.

The early history of LP gas dates back to about 1890. Before this time, the light ends of the crude oil were largely a waste product and a drug on the market since most crude oil was then processed for kerosene and lubricating oils. The advent of the automobile opened up a market for gasoline to utilize part of the light ends, but the light materials, butane and propane, which constitute LP gas were hard to handle and refineries still resorted to the practice of allowing them to be wasted.

The first attempts to liquify these gases were made about 1903. Herman Blau, a German, liquified a very high pressure gas which was called "Blaugas" which contained ethane, butane, and propane. About 1910 A. N. Kerr began experiments in the compression of these waste gases and bottling them as a fuel. The bottleneck was the high pressure required; as high as 700 to 1000 psi were not uncommon. Better processes were developed so that the very light hydrocarbons could be separated. As a result, during the period between 1922 and 1928, the industry standardized on propane and it was referred to as "bottle gas" fuel. It was and still is widely used on farms for lighting and cooking.

By 1935 the increased use of this fuel called for larger containers or tanks in order to make deliveries economical. These storage tanks were of the underground and above-ground types. About this time, the lower pressure gas, butane, was flooding the market, so that butane, propane, or mixtures of both were made available. The war consumed large quantities of butane for aviation fuel, and this made it scarcer. There are indications that it may continue to be more scarce than propane since there is a growing demand for it in many synthetic production industries.

The physical properties of these fuels are shown in Table 1.

TABLE 1. PHYSICAL PROPERTIES OF TWO LP GASES

Properties*	Propane	Butane
Formula	C_3H_8	C_4H_{10}
Boiling point of liquid at atmospheric pressure	−44 F	+32 F
Pounds per gallon of liquid at 60 F	4.23	4.86
Btu per gallon of liquid at 60 F	91,700	103,400
Btu per pound of gas	21,690	21,340
Btu per cu ft at 60 F and 14.696 psi abs	2,521	3,267
Cu ft of gas (60 F, 14.696 psi abs) per lb of liquid	8.59	6.51
Cu ft of gas (60 F, 14.696 psi abs) per gal of liquid	36.5	31.8
Vapor pressure, psi gage		
(a) 60 F	92	12
(b) 100 F	172	37
Specific gravity of gas, compared to air	1.52	2.00
For complete combustion, pounds air per pound gas	15.7	15.5

*Handbook Butane-Propane Gases, third edition (1945).

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Power and Machinery Division.

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AUTHOR'S NOTE: Acknowledgement is made of the helpful suggestions made by F. C. Fenton; also the information contributed for this paper by O. L. Garretson, General Tank & Steel Corp., Roswell, N. M., William R. Thorne, Stanolind Oil Co., Tulsa, Okla., C. R. Dougherty, Phillips Petroleum Co., Bartiesville, Okla., R. H. Mahnke, Liquified Petrolcum Gas Assoc., Inc., Chicago, Ill.; and to J. O. Fairbanks, Fairbanks Sales & Service, Wichita, Kan., for supplying the necessary carbureting equipment for carrying on tests and assistance given in running tests.

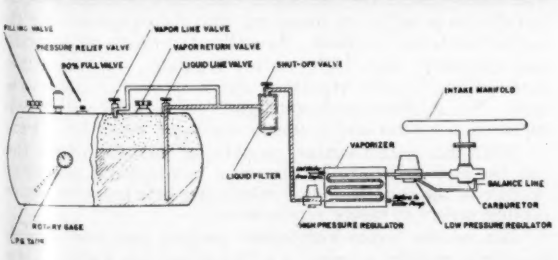
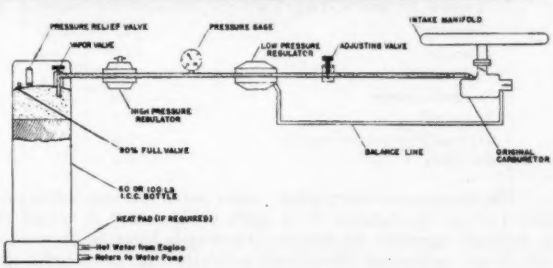


Fig. 1 (*Left*) Flow diagram of liquid-withdrawal system and a tractor equipped with this system • Fig. 2 (*Right*) Flow diagram of vapor-withdrawal sytem and a tractor equipped with this system



It will be noted that the boiling point of either fuel is well below normal atmospheric temperatures and pressures. At atmospheric pressure, propane is a gas or vapor at practically all temperatures likely to be encountered in the United States, but can be liquified by moderate pressures when placed in a container. Butane boils at about the freezing point of water, 32 F, and since its evaporation cools it somewhat, its liquid cannot supply vapor at a satisfactory pressure unless the surroundings of the container are at a temperature considerably above the freezing point of water. For this reason, butane is stored in underground tanks for domestic purposes, whereas propane is generally stored in aboveground tanks. An odorant is added to LP gases to aid in detecting leaks.

A question often arises as to the sources of this fuel. They are obtained from three principal sources: (a) natural gasoline plants where they are recovered from the dry gas and gasoline removed from crude oil (b) recycling plants where the wet gas is drawn from natural gas wells and (c) oil refineries where the crude oil is processed into commercial gasoline, fuel oils, and distillates.

At the present, there is considerable interest in utilizing this fuel in engines, particularly in areas within a few hundred miles of refineries where it originates. Of the four major domestic uses, cooking, refrigeration, water and house heating, house heating causes the peak consumption to occur in the winter. In areas such as Kansas, this has presented the industry with a "balanced load" problem. This also means that there is a need for huge storage facilities to carry them over the summer for the winter load. The present load ratio in Kansas as reported by the Kansas LP Gas Association is 3.9 to 1 (winter to summer) as of 1948. Data compiled through the efforts of R. H. Mahnke of the LP Gas Association and W. R. Thorne of the Stanolind Oil and Gas Co. show that converting 12.2 per cent of the tractors in Kansas would balance the load ratio between winter and summer. Any conversions in excess of 12.2 per cent would result in more sales of LP gas in summer than in winter. Also it has been estimated that, if 16.3 per cent of present tractors in the state of Kansas were converted to burn LP gas, the consumption would equal the present domestic consumption. It is estimated that there are approximately 48,000 tank gas and 32,000 bottle gas users in Kansas.

The increasing availablity and attractive price of such fuels affords an opportunity for the consumer to find more uses for it. Where large quantities of fuel, 500 to 1000 gal, are purchased, it retails as low as 9c per gal in parts of Kansas. At this rate, LP gas appears to be advantageous from a cost standpoint.

According to a survey by the Bureau of Mines, there are 3000 bulk plant installations in the United States, a number which is equal to the number of counties. Increasing the storage capacity at consumer's installations has aided in handling the greater amount of LP gas marketed. In 1948, 2,736,801,000 gal were consumed compared to 1,060,156,000 gal in 1944. From the same survey, it was learned that the increase in consumption in 1948 over that sold in 1947 was greater than the total quantity delivered during 1941. Also, according to this same report, finished petroleum products such as propane and butane are being transported in pipelines. Table 2 gives a breakdown of the rank of principal uses in 1948.

TABLE 2 PRINCIPAL USES OF LP GAS IN 1948

Domestic	53.8 per cent
Chemical	17.9 " "
Gas manufacturing	8.7 " "
Synthetic rubber	8.3 " "
Industrial	7.8 " "
Internal-combustion engines	3.4 " "
All other	0.1 " "

The question is often asked, what about the availability of this fuel in the future? It is quite obvious that it would be a difficult question to answer. Correspondence with one of the major petroleum companies indicates that potentially the supply is tremendous. The annual potential (based on gas and oil produced and processed) was estimated at approxi-

Fig. 3 Tractor equipped with heat pad under fuel container to overcome vaporization difficulties encountered with vapor-withdrawal system in cold weather

mately 14 billion gallons at the end of 1947. It has also been stated that the amount of potential product actually made available is naturally dependent on a number of economic conditions. The current rate of actual production is in excess of the current annual demand for these products.

Two years ago a project was started at Kansas State College for the purpose of studying the utilization of LP gas on farms. It was the direct result of inquiries received regarding its use. One phase of this project was to study the use of this fuel in power units. Data was collected from the field by means of a questionnaire sent to farmers and by tests run in the laboratory.

Since this fuel is relatively new as an engine fuel in tractors, very few replies were received from power users. Three thousand questionnaires were mailed to farmers in Kansas. One part of the questionnaire concerned its use for domestic purposes such as house heating, cooking, water heating, refrigeration, etc., and the other part was on power units. Of the 600 replies received, 31 reported using it as fuel in tractors and 45 as using it in stationary power units, most of which were light plants. Seventeen of the 31 tractors were reported as factory equipped to burn LP gas and 14 tractors were converted from gasoline to LP gas. Many of the units had been in operation only a short time since the average period of operation with this fuel was only 2.12 years, ranging from 1 to 10 years. The average cost of conversion units was $215.90, the range being from $135 to $285. The average size of tank used on tractors reported was 35 gal, and the average number of refills per 10 hr day was estimated to be 1.5 times. The estimated average annual fuel consumption for the 31 tractors reported was 2740 gal per year.

LP Gas Carburetion. There are in general two types of LP gas carburetion systems, those in which liquid is withdrawn from the fuel tank, and those in which vapor is withdrawn from the fuel tank. In either case, no fuel pump is needed as the vapor pressure is utilized to insure flow through the fuel lines.

The equipment for the liquid-withdrawal method is often referred to as the standard conversion. It is the same equipment that is available today, on a factory equipped tractor. The initial cost of the conversion equipment and labor for its installation is higher as compared with the equipment for the vapor-withdrawal method. Basically it consists of a special fuel container, filter, high-pressure regulator, vaporizer, low-pressure and/or zero regulator, and a special LP gas carburetor. Fig. 1 shows a flow diagram of a liquid-withdrawal carburetion system and a tractor equipped with this system.

With this system butane, propane, or mixtures of the two can be used satisfactorily for most atmospheric conditions because of the vaporizing unit which gets heat from the engine cooling system to insure vaporization.

Use of the vapor-withdrawal method has been limited because it requires propane or a fuel which has a much lower boiling point than butane, since the vaporizing unit has been eliminated. It is therefore limited to conditions whereby an

adequate amount of heat will be transferred to the bottle or container to offset the refrigeration effect which results when fuel vaporizes. Fig. 2 shows a flow diagram of the vapor-withdrawal method and a tractor converted to this system which has been recently placed on the market. It uses two pressure regulators; the first lowers the high-pressure vapor from the fuel container to an intermediate pressure, in which condition it passes through the second, a zero regulator, referred to as a fuel controller. The fuel controller is essentially a standard regulator with some minor modifications, mounted in an inverted position, and containing a variable restriction for mixture control. The original carburetor on the engine is used with this system. Since the regulator is mounted in the inverted position, this system operates on the principle of balancing the force of the inlet pressure at the orifice nozzle against the weight of the diaphragm and adjoining parts. The slight overbalance of the parts provides a shutoff of the fuel. The differential pressure created by the action of venturi in the carburetor lifts the diaphragm and allows fuel to flow at a pressure close to the air pressure at the inlet of the carburetor. It is claimed that the carburetor connection which requires a tube along the axis of the venturi restricts the area slightly, but will cause no noticeable loss of power except in rare instances when the venturi size is critical.

With this system it is possible to operate on gasoline whenever one should run out of fuel or maybe in extreme conditions such as cold winter weather when the LP gas may not vaporize readily. Operator had devised a heating pad which is placed under the fuel container when vaporization difficulties were encountered, such as operating during periods of low atmospheric temperatures. Fig. 3 shows a tractor which was equipped with a heat pad to supply heat when vaporization difficulties were encountered. The location of the bottle in front of the radiator aids to keep air flowing by the container, which results in better heat transfer, and apparently does not restrict air flow through the radiator.

Desirability of LP Gas as an Engine Fuel. Reduced engine wear, which results in increased engine life and lower repair costs, appears to be one of the advantages of this fuel. First, this fuel enters the engine cylinder as a dry gas which eliminates all tendency for crankcase dilution. Less carbon is accumulated in the combustion chamber which tends to keep the oil from being contaminated with carbon, hard carbon particles, and fuel. This means that fewer oil changes are needed. Less carbon accumulation is explained by the fact that the fuel is essentially a simple hydrocarbon, so incomplete combustion of heavier ends of fuel are not likely to be present.

Since this fuel enters the carburetor as a vapor, more complete mixing of the air and fuel is accomplished which results in more complete combustion. This one factor alone will increase thermal efficiency. This fact is brought out by results of tests in the laboratory shown later in this paper. The high anti-knock quality of butane or propane is another decided advantage, especially in higher compression engines. Table 3 shows the octane number by the various methods used for determining its anti-knock value. It will be noted that the octane number is near 100 which is desirable for compression ratios of 7 to 1 and higher.

TABLE 3. KNOCK RATING OF PROPANE BY VARIOUS METHODS*

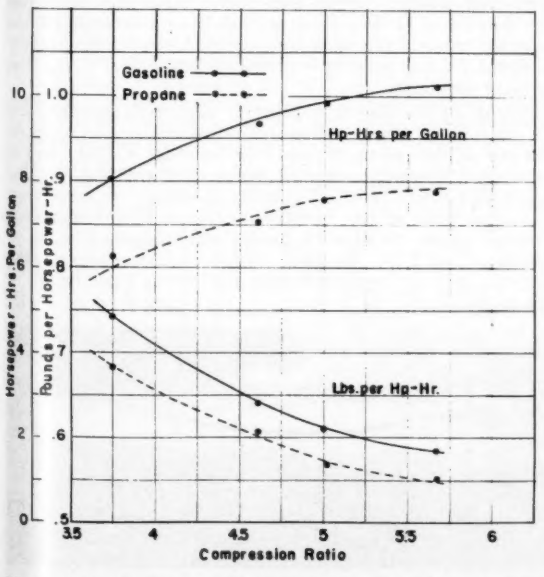
Method	Knock rating of propane MI tel in iso-octane	Equivalent octane no.
Research (f-1)	1.90	111.8
ASTM (motor)		97.1
F-3 (1-C)	0.08	101.7

* Reported by National Bureau of Standards.

Less carbon monoxide in exhaust gases is present with this fuel. During tests in the laboratory it was noted that less disagreeable fumes were present when the engine was run on LP gas than on gasoline.

Operators have reported as little as one-third as much cylinder wear in power units operating on LP gas. They also reported less valve trouble and cleaner crankcases. Experience has shown that operating on too lean a mixture may cause burning of the valves. It is therefore important that the proper mixture be obtained. Some servicemen have found the exhaust gas analyzer to be advantageous if used properly. Estimated engine life was reported to be from one-third to three times longer than for engines using gasoline.

Since this fuel enters as a dry gas into the cylinder, there is considerable speculation whether or not there is a definite need for upper or top cylinder lubrication. Replies to questionnaires from operators in the field on this subject indicated it may not be necessary under certain conditions. Out of 45 power units and 14 tractors converted to burn LP gas, four operators indicated that they had provided for upper cylinder lubrication. One of these operators had started out using a top-cylinder lubricator but had stopped using it. Some operators have expressed the opinion that upper cylinder lubrication



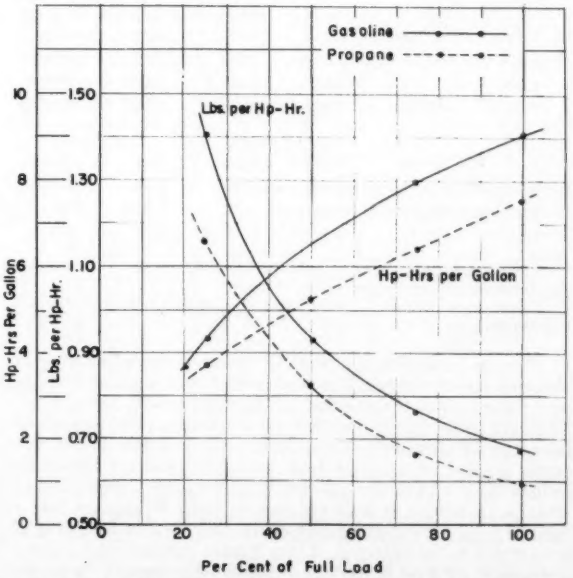


Fig. 4 (*Left*) Comparative fuel consumption data on Hercules engine at full throttle, rated speed 1200 rpm • Fig. 5 (*Right*) Comparative fuel consumption data of 2-plow tractor with 5.9:1 compression ratio

is advantageous during the breaking-in period of new or reconditioned engines, not only on LP gas but also on gasoline.

Another factor which is of vital importance and is much talked about is the Btu content of the fuel itself. For example, propane contains about 21,690 Btu per lb and weighs about 4.23 lb per gal, as compared to regular gasoline with about 20,290 Btu per lb and weighing about 6.12 lb per gal. These figures show a higher heat content per pound for propane. Since these fuels are sold by the gallon, it would seem to be more logical to compare them on a heat per gallon basis. Using this method of comparison, gasoline would have a higher heating value per gallon; 124,175 Btu per gal for gasoline and 91,749 Btu per gal for propane. This appears to be a disadvantage for the LP gas. However, this difference tends to even up with some of its advantages. From an economic standpoint the price differential of these fuels will definitely influence the total operating costs.

Since the fuel is in the vapor state when entering the cylinder, one can expect a slightly lower volumetric efficiency as compared to the engine operated on gasoline or the diesel engine in which a full charge of fresh air is taken in during the intake stroke. If pressure injection could be incorporated with LP gas, some improvement can be made toward increasing the volumetric efficiency.

Results of Tests in Laboratory. Due to the rapid increase of tractor conversions in Kansas during the last two summers, and in response to requests for comparative fuel consumption of liquid and liquified fuels, a series of comparative fuel consumption tests were run on a power unit which was designed to burn gasoline. Different cylinder heads were available so that the performance could be observed at compression ratios comparable to most of the present-day tractors. The ratios used, however, were comparatively low compared to the high-compression engines available today.

Tests were run with the engine equipped with a standard type conversion unit recommended for the size of engine used. No other changes were made to the engine. In each set of tests the ignition timing was adjusted for maximum power and the carburetor adjusted to give maximum power. Results of these tests are shown in Table 4 and Fig. 4.

TABLE 4. Comparative Power and Fuel Consumption of Hercules Engine, with Various Compression Ratios, Burning Regular Gasoline and Propane at Rated Engine Speed of 1200 rpm

Compression ratio	Maximum hp*	Fuel Consumption Lb per bhp-hr	Hp-hr per gal	Fuel cost, c per bhp-hr†	Gal fuel per bhp-hr
		Fuel — Regular Gasoline			
3.73	27.54	0.746	8.08	1.98	0.124
4.60	32.35	0.644	9.38	1.71	0.107
5.00	33.56	0.612	9.85	1.62	0.102
5.65	33.99	0.588	10.25	1.56	0.0975
		Fuel — Propane			
3.73	27.48	0.685	6.28	1.91	0.159
4.60	31.97	0.607	7.08	1.70	0.141
5.00	32.25	0.569	7.57	1.59	0.132
5.65	32.34	0.555	7.75	1.55	0.129

* Maximum horsepower corrected to standard sea level atmospheric conditions.

† Fuel costs per bhp hr were based on gasoline selling at 16c per gal and propane at 12c per gal.

It is to be noted that slightly less maximum power was obtained from propane. The specific fuel consumption was less on propane than for gasoline at the compression ratios used. The data show that higher thermal efficiencies can be expected from the LP gas, since it contains more Btu per pound and better mixing of air and fuel vapor is apparent. Propane weighs only 4.23 lb per gal which is a decided disadvantage when consumption is on a volumetric basis. It appears that a definite price differential between the two fuels is necessary if economy is to be expected. These figures indicate that a price differential of 4 or 5c per gal is needed for them to be on an equivalent basis with gasoline.

Similar tests were made on a two-plow tractor having a compression ratio of 5.9 to 1 and designed to burn gasoline. Results of these tests are shown in Fig. 5. No changes were made on the engine except for optimum spark timing to get maximum power. It was necessary to advance the time of ignition the maximum amount permissible with the slots provided in mounting flange of magneto. This is to be expected since the rate of flame propagation is slower for LP gas. There was little difference in maximum power of the two fuels, 23.65 hp on gasoline and 23.3 hp on propane. It was noted that the venturi in the carburetor used was 1/8 in larger than the one for gasoline which would tend to improve the breathing capacity of the engine at its maximum output. Specific fuel consumption, of course, is consistently less on propane, however, the gallons per horsepower-hour is greater because it contains less pounds per gallon than gasoline. Under the conditions of operation, a price differential of 3c per gal would put the two fuels on an equivalent basis. During the engine tests it was noted that there seemed to be a noticeable increase in power smoothness. Some operators in the field had noticed similar results and explained it by saying that the LP gas would not give quite the maximum power of gasoline, but would give better lugging ability on heavy loads.

Methods of Storage and Handling. Anyone who has anything to do with storage and handling of liquified petroleum gases should certainly acquaint himself with pamphlet No. 58 which is the standard of the National Board of Fire Underwriters. The rules and regulations set up by the state fire marshal should also be followed. In the questionnaires sent out to farmers, it was asked if LP gas was more hazardous than gasoline to handle. Out of 26 reporting, 3 said it was more hazardous and 23 said it was about the same or less hazardous than gasoline.

The proper handling of this fuel when filling the container on tractors, trucks, etc., certainly cannot be overemphasized. Twenty-three operators reported filling their tractor fuel tanks by bleeding vapor off with the liquid level valve and utilizing the resulting differential vapor pressure between the supply and tractor tanks to force liquid into the tractor tank. Considerable time was saved if the operator would refill the tractor container as soon as possible after stopping the engine. With the vapor-withdrawal method, the tractor container would be at a lower temperature and the remaining fuel would then have a lower vapor pressure which would facilitate filling. With the liquid-withdrawal method, it is necessary to change over to vapor withdrawal for a short period prior to stopping the engine. One operator reported using a vapor return line connected between supply and tractor tanks and permitting the liquid fuel to flow by gravity to the tractor tank. Seven reported using a special liquid pump. Using a liquid pump designed for this purpose is probably the quickest method for refilling containers.

Adapting the Engine to Burn LP Gas. It is probably safe to say that we already know what features should be incorporated in the engine of tomorrow in order for this fuel to be utilized efficiently, some of which are (a) LP gas carburetion equipment, (b) cold intake manifold, (c) optimum timing of ignition, (d) cold-type spark plugs, (e) high-compression ratios, 7.0 to 9.0:1 having been suggested by. E. A. Jamison and J. R. Strother. Higher ratios may be used, and this will no doubt be determined by the basic design of the engine. *(Continued on page 222)*

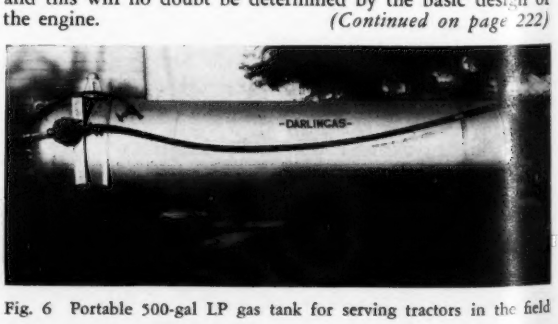


Fig. 6 Portable 500-gal LP gas tank for serving tractors in the field

Cotton Mechanization in California

By J. P. Fairbank and K. O. Smith
MEMBER A.S.A.E. JUNIOR MEMBER A.S.A.E.

IN 1949, COTTON ranked first in value among the field crops of California when 1.3 million bales were produced on 957,000 acres, all irrigated (Fig. 1). Production costs are high, however, because of land values, wage scales, and irrigation charges. Reduction in unit costs of the product lies in successful mechanization and high yields.

The cotton-producing area of the state is in a favorable period of development for a mechanization program. The farms are large enough to justify fairly large investments in in field machinery, shop facilities, and year-round employment of operating and supervising personnel. The production of crops other than cotton is already mechanized. Implement dealer service is good. The fields are large and quite level. The climate is semiarid. Rains occur only in the early spring and late fall. The boll weevil has not invaded California. The fact that yields in California are two and one-half times the national average helps to keep down unit costs—a point especially important in mechanical picking.

Preliminary investigations of mechanical picking of cotton were conducted during the period of 1928 to 1932 by agricultural engineers of the California Agricultural Experiment Station. The project was reactivated in 1946 through a cooperative agreement between the agricultural experiment station, Agricultural Extension Service, and a large cotton factor. In 1948, it was reorganized to include the Bureau of Plant Industry, Soils and Agricultural Engineering, USDA and the California Planting Cotton Seed Distributors. The scene of operations was shifted to the U. S Cotton Field Station near Shafter, where a plant-breeding program has been under way for many years. The personnel includes engineers, agronomists, plant breeders, botanists, entomologists, and agricultural extension workers. Equipment is supplied by the cooperating agencies, together with manufacturers and distributors of farm machinery. A cotton mechanization committee, composed of nine men representing various producing, processing and marketing groups in the cotton industry, acts in an advisory capacity.

The objectives of the current program are to learn how to grow and handle the crop in a manner best suited to mechanization and to assist in adapting machinery to irrigated cotton. Since mechanical harvesting offers the greatest possibilities in reducing labor requirements, emphasis is being given to cultural methods that can aid mechanical harvesting without reducing yields.

It is a common observation that machine pickers leave a disproportionate amount of the crop near the ground. If the bolls were higher on the plant, picking efficiency would be improved, and the pickerhead could run higher off the ground, thereby reducing damage to the spindles from dirt and clods. Less vigilance would be required on the part of the operator to keep the height of the head adjusted with the great precision now necessary. In addition, the number of bolls degraded on account of dirt and trash would be greatly reduced.

Two possible approaches toward forcing the set of bolls higher on the plant are (a) through plant breeding and (b) by cultural methods. Though plant breeders are making progress on the problem, it takes time. Cultural practices, however, can be put into effect at once, if the grower knows what to do.

The data from a study of 6 strains of Acala cotton at the Shafter station in 1948 offer ample support for the point that losses from machine picking are concentrated in the zone near the ground. An average of 19 per cent of the crop was in the lower 6-in zone. Hand gleanings after picking were as follows:

From the lower 6 in	41 per cent
From above 6 in	17 per cent
Shatter	42 per cent

("Shatter" is bolls and locks dropped on the ground and locks removed from the burrs but left clinging to the plant.)

Plant Population. Of the various cultural practices studied, population has had the most effect on plant characteristics as measured by the height above the ground of the first node bearing a fruiting stem or branch. Data on two series of tests in 1949 are given in Table 1. In the first series, a heavy stand of seedlings was carefully hand-thinned to single plants spaced 4 in, 8 in, 12 in and 16 in apart. In the second series the crop was planted to a stand at seeding rates of 4.1 to 13.5 lb per acre, continuously drilled and unthinned. Acid delinted seed was used in these tests to give a more uniform distribution than was possible with the machine delinted seed which was used in all the other tests. In both groups, a consistent raising of the first fruiting nodes occurred with

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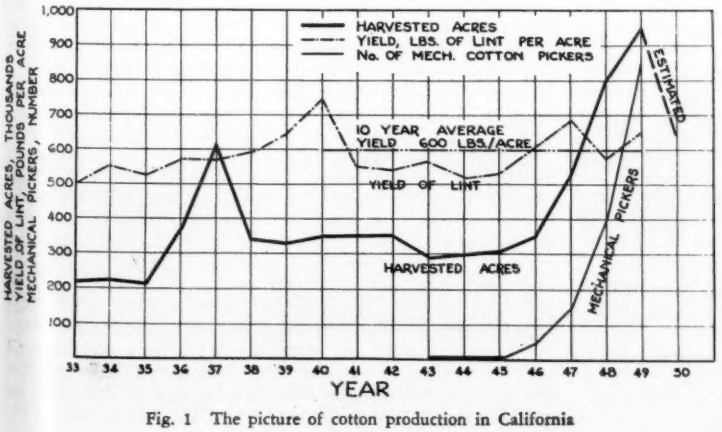

Fig. 1 The picture of cotton production in California

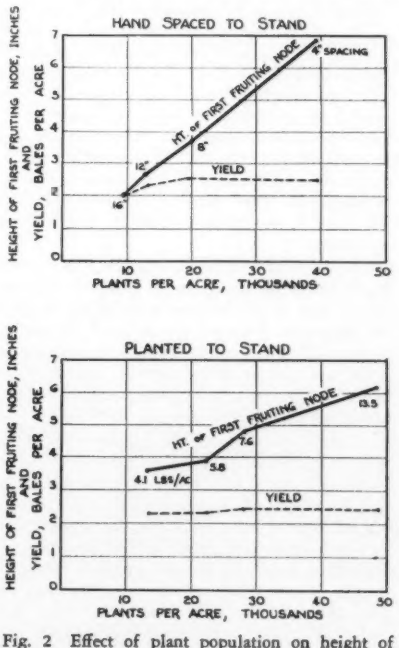

Fig. 2 Effect of plant population on height of first fruiting node

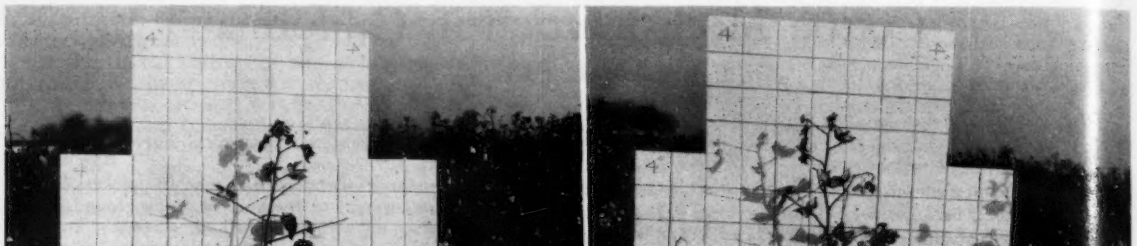

Fig. 3 Effect of spacing on shape of plant. Typical plant in row (*left*) where the average spacing was 4 in and (*right*) where the average spacing was 16 in

TABLE 1. SPACING VERSUS HEIGHT OF FIRST FRUITING NODE

Hand Spacing:	4 in	8 in	12 in	16 in	
Plants per acre, thousands	39.3	19.3	13.1	9.8	
Height of 1st fruiting node, in	6.8	3.6	2.7	2.0	
1st picking yields, bales per acre	2.52	2.58	2.32	2.06	
1st picking per cent efficiency	95.0	93.6	94.2	94.3	
Seeding Rates, lb per acre	13.5	7.6	5.8	4.1	12.6*
Plants per acre,thousands	48.9	28.1	22.2	13.3	48.6
Average spacing, in	3.2	5.6	7.0	11.8	
Height of 1st fruiting node, in	6.3	4.8	3.9	3.6	6.2
1st picking yield, bales per acre	2.47	2.45	2.35	2.30	2.34
1st picking, per cent efficiency	93.0	93.0	92.7	92.3	93.9

* Hill dropped 14 in centers

the greater plant population (Fig. 2). The closely spaced plants developed small laterals with the bolls well distributed along the main stem; the widely spaced ones had heavier branching with more of the crop near the ground. The yields per acre were slightly higher for the thicker stands. Fig. 3 shows the typical differences between plants spaced at 4 and 16 in apart.

It will be noted that there was no significant difference in the machine-picking efficiency. It is suspected that the machine operator was too good for the purpose of the experiment. In addition to being a skillful operator, he knew that the machine would be followed by hand gleaners and used great care to keep the picker head just skimming the surface, thus leaving few of the lower bolls. Furthermore, the beds had practically no clods and weeds, and the contour was good for machine picking. In other words, the conditions were more favorable for good recovery than could be expected on an average ranch operation.

Bed Planting vs. Flat Planting. A mechanical picker should work better on bed-planted than on flat-planted fields. In the latter, dirt is thrown up around the base of the plants when the irrigation furrows are formed. In bed planting, the furrow is formed prior to planting. Measurements during the past four years indicate somewhat higher fruiting on plants on beds, but as yet there have been no consistent differences in either picker performance or yields.

Mechanical Thinning. Machine thinning and cross blocking were compared with hand thinning and no thinning at all. Under the soil and moisture conditions of the tests, no evidence was found that thinning improved either the yield or the picking efficiency of the machine. As a matter of fact, there seemed to be a slight advantage in no thinning at all, except for a little less trash in the seed cotton picked from the thinned stands. From these results, it is believed that for sandy loam soils at least, the only justification for thinning is for weed and grass control—the thinning operation being an early cultivation in the drill row.

Tests at Shafter this year also compared two types of mechanical thinners ("choppers") with hand thinning. The soil was a sandy loam, easy to till, and the original stand was excellent. The machines used were a trailer-type Dixie cotton chopper and the Mayco which is merely a wheel with knives attached to its periphery and clamped to the cultivating tool bar, angular to the line of travel. The machines removed from 57 to 67 per cent of the original stands, leaving hills with average spacings of 10.8 to 12.8 in. The average hand spacing was 10.8 in. The final results in yields and picking efficiencies (Table 2) were practically identical.

TABLE 2. THINNING METHODS

	Dixie-thinned	Mayco-thinned	Hand-thinned
Plants per acre, thousands	31.6	25.8	19.3
Average hill spacing, in	10.8	12.8	10.8
Average number plants per hill	2.2	2.1	1.3
First picking yield, bales per acre	2.81	2.83	2.83
Picking efficiency, per cent	94.7	95.0	95.0

Weed and Grass Control. As in other states, the problem of weed and grass control is of prime importance in California. Although there are no midsummer rains to encourage weed growth and prevent field operations, late summer growth results from frequent irrigations after cultivations have ceased. The weeds and grass not only compete with the cotton plants for water and soil nutrients but also reduce the harvesting efficiency of the picker and lower the grade of the ginned cotton.

Cultivation with two- or four-row tractor-mounted cultivators is the cheapest method known. It is very effective if done when the seedlings are small. Summer annuals in the drill row can be controlled by throwing just enough dirt to cover them. Under furrow irrigation, the light layer of surface soil dries out and prevents the germination of seeds.

Late cultivation—after the usual "lay-by" time—can do much to reduce the crop of weed seeds for next year, as well as to give cleaner fields for the harvest of the current year. The natural objection to late cultivation is the possibility of damage to the large plants by the tractor cultivation. This damage, however, may be less than has been believed. Some late cultivating was done this year in 44-in cotton with a shielded tractor, which had only 18 in vertical clearance. The yield of these plots was 2.81 bales per acre against 2.83 for the check. The picking efficiencies were 94 and 95 per cent, respectively. There is considerable interest in the possibilities of high-clearance and shielded equipment for late cultivation.

"Dirting" cotton, or "wrapping it up," is a common and effective method of weed control. It is hoped, however, that this practice will not be necessary because of its effect on mechanical harvesting. In the 1949 tests, heavy dirting de-

creased the effective clearance of the crop above the ground and lowered the picking efficiency, as shown by the following results:

	Heavily "dirted"	Control
Height of first fruiting node	3.2 in	6.0 in
Picking efficiency (first picking)	92.3 per cent	95.0 per cent

Chemical Weed Control. Chemicals used for weed control are divided into two classes: (a) general contact weed killers and (b) selective weed killers. All of the oils belong in the former; TCA (trichloroacetic acid) and maleic hydrazide, in the latter. Like other methods of weed control, chemical herbicides give best and most economical results on young weeds only 1 to 2 in high. In the 1949 experiments, several chemicals were tested for their effectiveness as weed killers and for their influence upon crop yield. They were applied unshielded at the rate of 60 to 80 gal per acre with a hand-drawn, power-operated plot sprayer, under a pressure of 40 psi. All of the oils gave good weed control; maleic hydrazide, which is a growth inhibitor under greenhouse conditions, proved ineffective in these field tests. The 10-lb rate of TCA gave fair control. Although most of the sprays resulted in yields somewhat lower than that of the check plot (Table 3), only the 30-lb rate of TC gave a significant decrease.

Single applications of the sprays were made on the Shafter plantings two weeks after the last cultivation. With this lapse of time, the weeds had not grown over 2 in tall. No further seedlings came up during the season.

Two main problems are encountered in late weed control work; first, traversing the fields without undue injury to the cotton, and, second, applying the chemicals to the weeds and not the leaves of the cotton. The Essick Mfg. Co. furnished a high-clearance, self-propelled sprayer that moved through rank cotton without injuring it. This year it was equipped with a set of experimental shields mounted on small wheels and inclined at about a 35-deg angle. The shields covered the full row width and were adjustable for height. Nozzles mounted under the shield were adjusted to give any desired coverage. Only the base of the cotton stalk was sprayed with the chemicals.

Flaming. This method of selective weed control may be used as soon as the cotton is tough enough to withstand the heat. The Mississippi Agricultural Experiment Station recommends that the plant be 8 in high and 3/16 in in diameter at the base of the stalk before flaming is used. It is very effective on small-bladed grasses and on weed seedlings that have not become established. If flaming is delayed until the weeds are too large, it will have little value.

In 1948, flaming gave good control in fields infested with Bermuda grass and raised the grade of the cotton. This increase in grade was offset, however, by the decrease in yield. The latter was attributed to one or more of the following factors: (a) the cotton was flamed when the air temperatures were too high (over 100 F); (b) the first application was made when the cotton was too small; (c) the flame was applied while the cotton was in moisture stress.

The 1949 plots were laid out to determine the reason for the decrease in the 1948 yield. Flamings were applied at weekly intervals, beginning when the stalk averaged 3/16 in in diameter at the base.

The effect of time of first flaming was investigated in a series of treatments wherein one set received its initial flaming June 17, another set a week later, and a third set two weeks later. The control was not flamed. Another series of plots was flamed in the morning, compared with afternoon flaming, the differences in air temperature being 15 to 20 F. Others compared flaming before irrigation with flaming after irrigation. All treatments were cultivated and hand hoed alike so that flaming was the only variable. The net result was no significant difference in yield or picking efficiency.

Row Profiles. Meek* has stated repeatedly: "Mechanized farming must be precision farming." The truth of this statement has been duly impressed in our attempts to grow cotton for machine harvesting. The rows must be uniform as to spacing, height, and profile. An implement adjusting platform with row lines marked on it, promoted by the Mississippi Delta Branch Experiment Station, is of great assistance in setting planters and cultivators. The 40-in row spacing used in the California trials should, in the opinion of the authors, be adopted by growers as a practical standardization measure helpful to them as well as to the farm machinery industry.

The final row profile is made, of course, by the last cultivation, but its shape should be anticipated in seedbed preparation because, in the final analysis, the fill must balance the cut. A few suggestions on row profiles are as follows :

1 The rows should be uniform in height, width and shape

2 They should be smooth and free of clods

3 The crest should be at the base of the stalk

4 Furrows should have wide bottoms to permit steering the picker.

Smooth row profiles were made at Shafter this year by the simple expedient of welding "whiskers" of 3/8 in round rod to the wing ends of 22-in sweeps used for the last cultivation. The rods extended within an inch or two of the cotton stalk.

Clods or chunks of hardpan are a detriment in the cotton row. Even if they should cause no serious breakage of the picker, they can clog the machine, increase the wear on the spindles, and damage the lint.

Defoliation. It is generally agreed that preharvest defoliation is highly desirable for early picking by machine. The application of defoliants in California is mainly by fixed-wing airplanes, although a few helicopters are used. Many trials

TABLE 3. EFFECT OF CHEMICAL WEED CONTROL AGENTS ON YIELD

	Weed oil	Stove oil	Fortified diesel oil	Trichloro-acetate		Maleic hydrazide		"Carrot" oil	Check
Gal per acre	65	65	88	63	63	61	60	70	—
Gal or lb active material per acre	65	65	35	10	30	3.3	6.6	70	—
1st picking yield, bales per acre	2.47	2.60	2.64	2.60	2.43	2.67	2.66	2.62	2.67

* Meek, W. E. and B. B. Ewing: Line-Diagram Method for the Setting of Farm Implements. Cir. 138, Mississippi Agricultural Experiment Station, pp. (Feb. 1948).

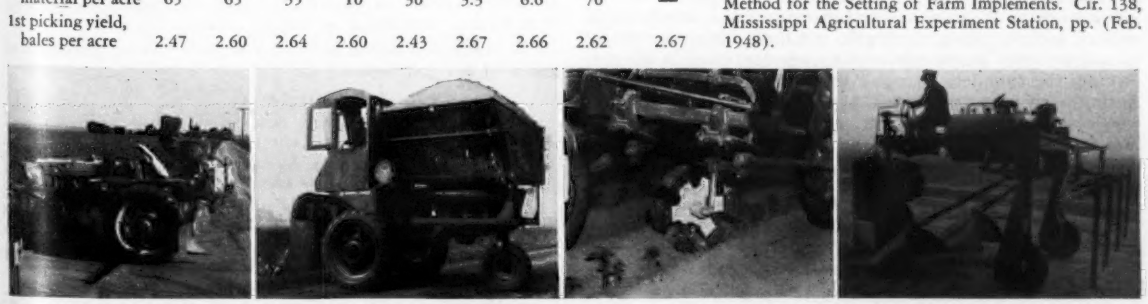

Fig. 4 (*Extreme left*) Crop duster mounted on a high-clearance cotton picker tractor. The blower is driven by the power take-off • Fig. 5 (*Left*) International cotton picker equipped with a cab. Grates replace the solid sheet on the sloping side of the basket to allow escape of fine trash • Fig. 6 (*Right*) the Mayco cotton chopper • Fig. 7 (*Extreme right*) Essick high-clearance sprayer with shielded nozzles for weed spraying in cotton. The rear boom is for spraying of insecticides and defoliants

have been made using a wide variety of defoliants, both as dusts and as sprays applied by airplanes and by high-clearance ground dusters and sprayers. The results have been erratic and inconsistent. It appears now that the plant physiologists must determine the fundamentals of artificially inducing the abscission of leaves. Complete and dependable defoliation will be an important factor in improving the quality of machine-picked cotton.

Mechanical Harvesting. Machine harvesting offers the greatest opportunity in reducing the labor requirement in California cotton production. Table 4 is compiled from time studies on the Cardwell farms near Kerman in 1948.

TABLE 4. LABOR INPUT PLANTING THROUGH HARVESTING

	Man-hours per acre	
	Machine picked	Hand picked
Planting and miscellaneous	2.4	2.4
Machine cultivating	3.4	3.3
Hand hoeing	16.1	16.0
Irrigating	13.3	22.0*
Picking	5.4	129.6
Totals	40.6	173.3

* This item is higher mainly because the irrigator's time was used less efficiently on the hand-picked field. It should be identical with that in the machine-picked fields.

Adjusting for the discrepancy in irrigating time, the machine harvesting saved 124 man-hours per acre. The yield was 2¼ bales per acre, one bale more than the state average for 1948. The higher yields are very favorable to the machine method.

The total costs of the mechanical harvesting method in the 1948 tests were divided as follows:

Operating	25 per cent
Overhead	20 " "
Field loss	20 " "
Grade reduction	35 " "

Field loss and grade reduction based on values in excess of hand picking amounted to more than all machine costs, amortizing the picker attachment over a 5-yr period and the tractor in 10 yr. The item of grade reduction is the most important, about one-third of the total. Incidentally, the machine picking in 1948 came out with a good profit—a cost of $2.05 against $3.37 for hand picking, a saving of $1.32 per hundredweight of seed cotton.

In 1949 approximately 800 spindle-type pickers were at work in California at the beginning of the season, and about 50 more came in later. The majority of these machines were Internationals. A few Allis-Chalmers two-row pickers worked the whole season, and a few of the new Rust machines arrived at midseason. It is estimated that between 12 and 15 per cent of the present crop will be picked by machine. The general comment of the industry is that the results of mechanical harvesting, both as to field recovery and grades, are superior to those of last year. The improvement is attributed to several factors: More favorable weather, better stands of plants, a higher percentage of the crop harvested in the first picking, the complete change-over to the new 4-42 strain of Acala, machine improvements, experienced and better trained operators. It is possible too that growers have exercised greater care in leaving the beds in better condition and in selecting the fields to be picked by machine. On the California Station this year, the field recovery (first picking) was above 90 per cent, a number of the plots averaging 95 and 96 per cent. The grades were 21 per cent Middling or Middling Plus; 56 per cent Strict Low Middling; and 23 per cent Low Middling. The improvement in field recovery was gratifying, but the grades obtained were disappointing, although on the whole, they are the best obtained in the four years of testing mechanical pickers.

Mechanical harvesting has received general acceptance this year by the cotton industry. Many who have questioned it heretofore now agree that "it's here to stay". The improved situation is attributed in no small part to the intensive educational program on picker operation and maintenance conducted by the manufacturer, the branch houses, and the dealers. The state agricultural extension service also gave valuable assistance.

The training program was promoted by the Cotton Mechanization Advisory Committee. The total attendance at the various schools was about 800 operators, owners and ranch foremen.

Machine owners, dealers, and local shops have made improvements to meet their needs, such as replacing the sheet-steel side of the basket with grates to allow more fine trash to escape; installing cabs, some equipped with heaters, to protect the drivers from wind and cold; placing mirrors and lights in such a way that the driver could see important spots from the seat. Some have mounted dusters, sprayers, burners and cultivators on their high-clearance picker tractors.

SUMMARY

1 Cotton is now a crop of major importance in California.

2 The conditions are favorable for mechanization.

3 The cotton mechanization program presently is aimed at cultural practices to fit farming by machines.

4 Weed and grass control is of uppermost importance of the various cultural problems.

5 Mechanical harvesting is the most important item in reducing hand labor requirements.

6 Tests indicate that close spacing produces plants desirable for machine picking, yet does not reduce yields.

7 The picking efficiency of machines now approaches that of hand picking.

8 The most important field for advancement lies in improving the quality of machine-picked cotton.

9 Mechanical pickers are being accepted with rapidity.

10 Training in the mechanical method is essential to success in cotton mechanization.

LP Gas as a Farm Engine Fuel

(Continued from page 218)

SUMMARY

1 Results of survey indicate that operators were satisfied with the performance obtained from engines converted to burn LP gas.

2 Reduced engine wear, and increased engine life is evident.

3 High anti-knock qualities of fuel makes it adaptable to the present trend to higher compression engines.

4 In order for the operating cost, based on consumption alone, to be on an equivalent basis for tractors converted in the field it appears that LP gas should sell from three to five cents less per gallon than gasoline, depending on characteristics of the engine.

5 Due to slower rate of combustion with propane, it is usually necessary to advance the time of ignition as much as 5 to 10 deg, depending on engine characteristics.

6 LP gas is bested suited for engines having compression ratios of 6:1 and higher.

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Supplemental Heat in Mow Drying of Hay (Part III)

By Roy B. Davis, Jr., G. E. Barlow, Jr., and D. P. Brown
JUNIOR MEMBERS A.S.A.E.

A PAPER (Part II of this series) was published in AGRICULTURAL ENGINEERING for June, 1948, giving an analysis of the factors affecting the use of supplemental heat in barn drying of forage crops by investigators assigned to the cooperative forage drying project of the Farm Electrification Division (BPISAE) U. S. Department of Agriculture, and the Virginia Agricultural Experiment Station(1)* These studies have been continued in an effort to broaden this analysis.

The above-mentioned paper presents a method of analysis whereby the time required to dry a given amount of long or chopped hay under a given set of conditions could be computed if the conditions under which it was to be dried were known. This method also could be used to determine the amount of hay which could be dried in a given time if the condition of the hay and conditions under which it was to be dried were known. Basically, this method consisted of a set of dimensionless curves which gave the relationship between moisture content, time, and amount of hay. By means of formulas and charts, the parameters necessary to use these curves could be determined. The values of these parameters were affected by such factors as the initial moisture content of the hay, the final moisture content desired, temperature and humidity of the air used for drying, the amount of air, and the drying rate and equilibrium moisture content of hay under the conditions used for drying.

A thorough study of the previous paper is recommended in order to become more familiar with the basis of this analysis; however, to summarize the paper briefly, the observed drying curves of 96 batches of hay, arranged in 32 columns of three layers each and dried under different conditions, were combined into the general set of curves described above. The temperature of the air entering the hay in this series of tests was thermostatically controlled at a constant value for each column. The ordinate of these curves is the change in moisture content during drying expressed in terms of a "moisture content ratio." The moisture content ratio is the ratio of the moisture content yet to be removed at any time to the total moisture content change and may be expressed by the formula:

$$\text{MCR} = \frac{\text{MC (dry basis) at time X} - \text{equilibrium MC (db)}}{\text{Initial MC (db)} - \text{equilibrium MC (db)}}$$

Moisture content expressed on a dry basis is used in this formula because of the linear relationship between the water removed from a material and its moisture content expressed on this basis. Drying time is the abscissa and is expressed in terms of "time units." A time unit is defined as the time in hours required for fully exposed hay to dry halfway to its equilibrium moisture content. This drying time is dependent on the temperature and humidity of the drying air and was shown in the previous paper for only a few conditions. The various curves on this chart show the drying rate for various depths of hay in the column. These depths are expressed as "depth units." A depth unit is defined as containing enough hay that, if all the theoretically available heat could be used, it would dry to equilibrium in the time taken to dry fully exposed hay halfway to equilibrium. From this definition the number of pounds of hay contained in one depth unit is

$$G = \frac{Q \times \Delta T \times Sa \times H}{0.01 \times \Delta M \times V}$$

where G = pounds of dry matter in a layer of hay one depth unit deep
Q = volume of air in pounds per hour
ΔT = maximum temperature drop that may occur in the air, or the difference between the wet and dry-bulb temperature of the entering air
Sa = specific heat of air
H = time in hours required by fully exposed hay to reach halfway to its equilibrium moisture
ΔM = initial moisture minus equilibrium moisture (per cent dry basis)
V = latent heat of drying, assumed to be 1100 Btu per lb.

In continuing this work the investigators ran a series of tests where the air was not thermostatically controlled but allowed to vary with outside ambient temperature with heat added at a constant rate. The object of this series of tests was to determine whether or not the same drying rate could be expected if the hay was dried with a temperature varying with ambient conditions as had been observed when the hay was dried at a constant temperature equal to the average of the varying conditions. It was felt that both conditions might be encountered on farms using supplemental heat for hay drying but that the condition where a constant amount of heat was added to ambient air would be more common. This would give a drying condition which would vary with the outside ambient temperature; for example, 30 F above the outside temperature at all times. The observed drying curves were analyzed by methods used in the earlier work. The resulting generalized curves (Fig. 1) were not appreciably different from those determined when constant temperature conditions were used. Before these charts were compared it was necessary to correct the chart shown in Fig. 6 of the preceding paper for the difference between the assumed value of several of the elements of data and the value determined experimentally. It might therefore be concluded that one could safely use the average or arithmetic mean of a varying temperature for this analysis when that temperature varies in the same manner as does outdoor ambient temperature.

A second series of tests was conducted to determine the drying rate of an exposed sample of alfalfa hay when dried under closely controlled conditions of temperature and humidity. A number of drying conditions in the temperature range between 60 and 170 F were used in this series. From these observed drying rates, the time required for the exposed hay to dry halfway to its equilibrium was determined. These are the values of a time unit, or H. These values are shown in Fig. 2 plotted on a psychrometric chart. To determine the value of H for any given operating condition, find the intersection of the dry-bulb temperature and the relative humidity of the operating condition and interpolate between the lines of constant H.

The same samples that were used to determine the drying

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* Numbers in parentheses refer to the appended references.

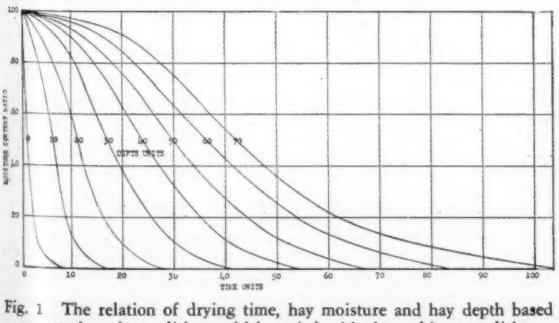

Fig. 1 The relation of drying time, hay moisture and hay depth based on entering air conditions which varied with the ambient condition

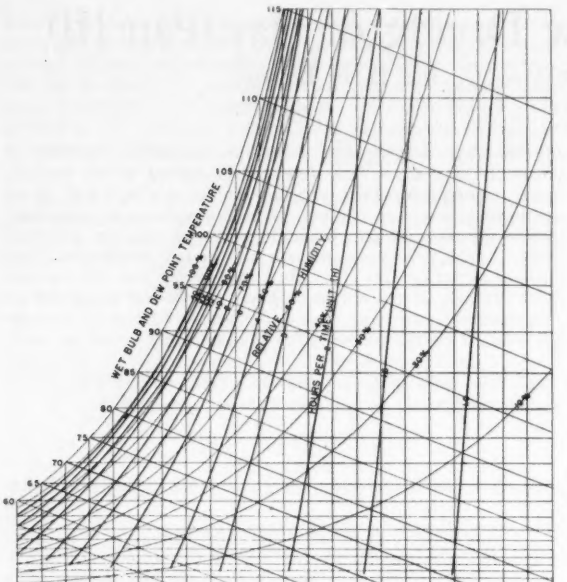

Fig. 2 Number of hours per time unit H for alfalfa hay for operating conditions between 60 and 150 F

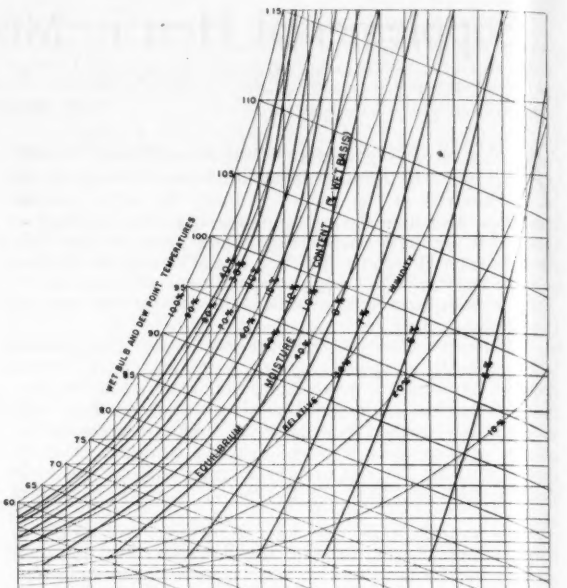

Fig. 3 The equilibrium moisture content (per cent wet basis) for alfalfa hay for operating conditions between 60 and 150 F

rates of fully exposed samples of hay were also used to determine the equilibrium moisture content of alfalfa hay under the various conditions of temperature and humidity by allowing the sample to dry until there was no change in the weight of the sample. The sample was then removed from the constant temperature, constant humidity oven and placed in a drying oven operated at 212 F until the weight again became constant. The moisture content of the sample when it was removed from the constant-temperature, constant-humidity oven was then computed on a wet basis and called the equilibrium moisture content of the sample for the conditions maintained in the constant temperature, constant humidity oven. These values are plotted on a chart similar to that in Fig. 2 and are shown in Fig. 3. To determine the equilibrium moisture content of alfalfa hay when dried under a given temperature and humidity, locate the intersection of the dry-bulb temperature and the relative humidity of the operating condition and interpolate between the lines of constant equilibrium moisture content.

Since the purpose of these data is to enable one to determine the performance of a hay-drying installation under various operating conditions, an example will be given to illustrate their use. Assume that 25 tons of alfalfa hay with a moisture content of 40 per cent (wet basis) is to be dried on a hay drier 1,000 sq ft in area. The weight of the hay is the weight after drying. It is to be dried by blowing air having a dry-bulb temperature of 80 F and a relative humidity of 50 per cent through it at a rate of 15 cfm per sq ft of mow area. Drying will be considered complete when the moisture content of the top layer reaches 20 per cent (wet basis). From the formulas given earlier for MCR and G, it will be noted that the items of data needed in addition to those assumed for the problem are the wet-bulb temperature of the entering air, the difference between the dry-bulb and wet-bulb temperature (ΔT), the specific volume of the entering air, the number of hours in a time unit (H), the equilibrium moisture content for the conditions under which we are operating, and the change in moisture content during drying (ΔM). The wet-bulb temperature and the specific volume of the entering air are determined from a psychrometric chart to be 66.8 F and 13.84 cu ft per lb, respectively. By subtracting the wet-bulb temperature (66.8) from the dry-bulb temperature (80), ΔT is determined to be 13.2 F. From Fig. 2 the value of H for 80 F and 50 per cent relative humidity is 8.8, and likewise from Fig. 3 the equilibrium moisture content for these conditions is 14.0 per cent (wet basis). The computations in this analysis were made using moisture content expressed on a dry basis; therefore, it is necessary that the initial, final, and equilibrium values given in this example be converted from wet basis to dry basis. This is done by computation or referring to Fig. 4 where it is noted that 40 per cent wet basis is equivalent to 67 per cent dry basis, 20 per cent wet basis is equivalent to 25 per cent dry basis, and 14 per cent wet basis is equivalent to 16.3 per cent dry basis. The change in moisture content during drying (ΔM) is determined by subtracting the equilibrium moisture content from the initial moisture content, and for this example is $(67 - 16.3)$ 50.7 per cent.

After accomplishing these preliminary calculations, substitutions may now be made in formulas for MCR and G to determine their values. When proper substitutions are made in the formula for MCR, it becomes

$$\text{MCR} = \frac{25 - 16.3}{67 - 16.3} = 0.173$$

Fig. 4 Conversion curve for use in converting moisture content (per cent wet basis) to moisture content (per cent dry basis)

Likewise, the formula for G becomes

$$G = \frac{\frac{15}{13.84} \times 60 \times 13.2 \times 0.24 \times 8.8}{0.01 \times 50.3 \times 1100} = 3.29 \text{ lb per sq ft}$$

The number of pounds in a depth unit (G) may be computed on an area of 1 sq ft or on the total mow area depending on the value used for the amount of air. If the amount of air per square foot is used, G will be in pounds of dry hay per square foot. If the total amount of air supplied to the mow is used in this formula then G would be in pounds of dry hay for the entire area. In this example G was determined to be 3.29 lb per sq ft. To determine the number of depth units involved in this drying, divide the weight of dry hay per square foot by the computed value of G. The number of depth units then equals 50 lb per sq ft ÷ 3.29 lb per sq ft per depth unit, or 15.2. It is next necessary to determine the number of time units involved in this drying. To do this enter the chart in Fig. 1 at an MCR of 0.173, move laterally along this line until it intersects the curve for 15.2 depth units (interpolate between 10 and 20). At this intersection, read the number of time units on the horizontal scale. This value is determined to be 13.4. The drying time is then determined by multiplying the number of time units (13.4) by the number of hours per time unit or H (8.8), and the result is 118 hr, or 4.91 days.

These same data and the same process of computation may be used to determine the amount of hay that might be dried in a given period of time. The parameters used to enter the chart in Fig. 1 in this case, however, would be MCR and the number of time units. Since in this case the drying time was assumed, the number of time units would be determined by dividing this time by H. By entering the chart in Fig. 1 with MCR and time unit, the number of depth units which would be dried in the given time could be read from the chart. The amount of hay which could be dried is the product of the number of depth units and G.

The method described above is quite tedious and for the occasional user would require considerable effort. With this in mind, additional charts have been prepared in which the results for a number of operating conditions are shown. The chart in Fig. 5 gives the time in hours required to dry 25 tons of hay when the initial moisture content is 40 per cent (wet basis), air delivery 15 cfm per sq ft, and the mow is 1,000 sq ft. Multipliers for different amounts of hay and varying initial moisture contents are also shown on this chart to enable the user to determine the results if his initial conditions are not as specified for these curves. The second chart, Fig. 6, shows the tons of hay which can be dried in 4 days when the initial moisture content is 40 per cent (wet basis), air delivery is 15 cfm per sq ft and the mow has the area of 1,000 sq ft. These values are shown by the solid lines on this chart. The broken lines on this chart give the amount of hay in tons per day to be added to or subtracted from the amount determined for 4 days if the drying time is more or less than 4 days.

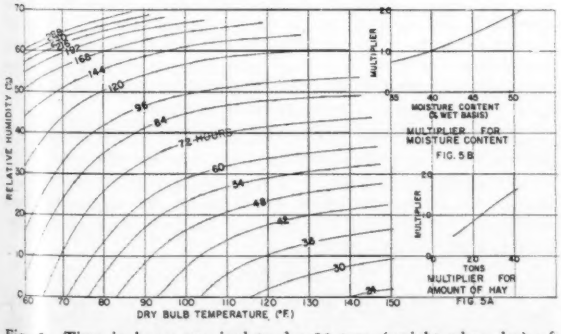

Fig. 5 Time in hours required to dry 25 tons (weight when dry) of long or chopped alfalfa hay from a moisture content of 40 per cent (wet basis) on a mow hay drier with an area of 1000 sq ft, when air is blown through it at the rate of 15 cfm per sq ft of mow area

A multiplier for moisture content is provided for use when the initial moisture content is not 40 per cent (wet basis). In these charts the weights referred to are for the hay after it has been dried. To use either of these charts, the user must know the amount and condition of the hay to be dried and the conditions under which it is to be dried.

To use the chart in Fig. 5, the user must know the amount of hay to be dried, its initial moisture content, the size of the mow, and the temperature and relative humidity of the air to be used for drying. The following example is given to illustrate the use of this chart: A mow hay drier 1200 sq ft in area is to be used to dry 36 tons of alfalfa hay. The initial moisture content of the hay is 45 per cent (wet basis). The air to be used for drying has a temperature and relative humidity of 100 F and 37.5 per cent respectively. This air will be blown through the hay at a rate of 15 cfm per sq ft of mow area, and the hay will be considered dry when the top reaches 20 per cent (wet basis). How long will the drying take under these conditions?

Since the conditions of this problem differ from those on which the chart was computed, namely, in size of mow, amount of hay, and initial moisture content, it will be necessary to adjust the time determined from the chart for each of these factors. First, convert the amount of hay to tons per thousand square feet which is 36/1.2 = 30 tons. On the chart the intersection of 100 F and 37.5 per cent relative humidity shows that 72 hr would be required to dry 25 tons of hay per thousand square feet from a moisture content of 40 per cent under these conditions. To obtain the time required to dry 30 tons per 1,000 sq ft from a moisture content of 40 per cent, multiply the basic time (72 hr) by the amount of hay multiplier (Fig. 5A) for 30 tons per 1,000 sq ft (1.21); this product is 87.1 hr. Then to adjust this time for 45 per cent initial moisture, multiply the time which has been adjusted for the amount of hay by the multiplier for moisture content. The multiplier for 45 per cent as determined from the curve (Fig. 5B) is 1.39 and the product (87.1 x 1.39) is 121 hr.

The data presented on this chart might also be used to select the proper temperature for drying a given amount of hay in a given time by manipulation of the parameters shown on this chart.

The data shown on the chart in Fig. 6 are intended to simplify the procedure in determining the amount of hay which can be dried in a given length of time when the condition of the hay and the conditions under which it is to be dried are known. Here again the solution of a problem using these data would best point out the use of this chart. How much hay can be dried from 45 per cent moisture content (wet basis) in 6 days using a temperature of 90 F and a relative humidity of 37.5 per cent? The hay will be dry when the top layer reaches 20 per cent (wet basis). The mow to be used has an area of 1400 sq ft.

Since the chart was based on the performance of a mow of 1,000 sq ft area, a time of 4 days and an initial moisture content of 40 per cent (wet basis), it will be necessary to adjust the chart value for each of these variations.

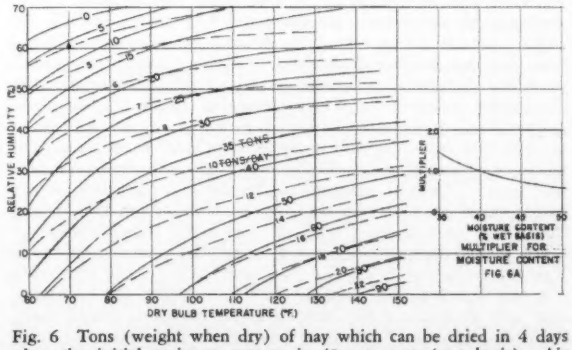

Fig. 6 Tons (weight when dry) of hay which can be dried in 4 days when the initial moisture content is 40 per cent (wet basis). Air delivery is 15 cfm per sq ft and the mow has an area of 1000 sq ft

TABLE 1. OPERATING COST OF DRYING LONG OR CHOPPED ALFALFA HAY

Size of mow, 1,000 sq ft — Amount of hay, 25 ton
Initial moisture content, 40 per cent (wet basis) — Air flow, 15 cfm per sq ft
Location, Richmond, Virginia — Time of year, June

Temperature, deg F	Relative humidity, per cent	Amount of supplemental heat, deg F	Time required, hrs	Electricity, kwh	Oil,* gal	Cost of electricity, at 2c/kwh	Cost of oil at 13c/gal	Total cost	Cost per ton
74.5†	66†	0	288	1440	—	$28.80	—	$28.80	$1.15
84.5	49‡	10	110	550	147	11.00	$19.10	30.10	1.20
94.5	35‡	20	72	360	193	7.20	25.10	32.30	1.29
104.5	26‡	30	55	275	220	5.50	28.60	34.10	1.36
114.5	19‡	40	45	225	240	4.50	31.20	35.70	1.43
124.5	15‡	50	39	195	260	3.80	33.80	37.60	1.50
134.5	11‡	60	34	170	272	3.40	35.40	38.80	1.55
144.5	8.5‡	70	30	150	280	3.00	36.40	39.40	1.58

† Mean temperature and relative humidity for June 1940-1948 inclusive, at Richmond, Virginia, taken from U. S. Weather Bureau meteorological reports.

‡ From psychrometric chart.

* Heating value of oil 120,000 Btu per gal. Includes estimated loss in heat transfer.

On the chart the solid line at the intersection of 90 F and 37.5 per cent relative humidity shows that 30 tons can be dried from 40 per cent (wet basis) in 4 days on a mow 1,000 sq ft in area under these conditions. By interpolating between the broken lines on the chart at the operating point of the problem, it can be determined that 8.4 tons of hay will be dried for each day above or below 4. In the problem with an assumed drying time of 6 days this correction factor for time is 8.4 tons per day multiplied by 2 days (6 - 4) or 16.8 tons. This amount is added to the basic amount and gives a total of 46.8 tons which can be dried in 6 days. To adjust this total for initial moisture content, determine the multiplier for 45 per cent moisture (Fig. 6A). This is found to be 0.72. The amount which can be dried per 1,000 sq ft from a moisture content of 45 per cent is the product of the amount adjusted for time (46.8) multiplied by the moisture content multiplier (0.72); this product is 33.7 tons. The last adjustment necessary for the solution of this problem is that of the size of the mow. The multiplier in this case is the ratio of the actual size of mow to 1,000 sq ft, or 1.4. After adjustment, the amount of hay which can be dried on a mow of this size under these conditions is 33.7 x 1.4, or 47 tons.

These data should be of value to the engineer in designing a barn hay drier, determining whether or not supplemental heat could be used to advantage and determining the most economical level of supplemental heat to use. The above illustrations should serve to point out ways in which these charts may be used for design purposes by enabling the engineer to predict the performance of the drier he is designing.

Determination of the practicability of supplemental heat in drying forage involves a consideration of a number of factors. Among these are the suitability of ambient conditions for drying, increase in drying rate when supplemental heat is used, cost of equipment, quality of forage produced with no supplemental heat and with varying amounts of supplemental heat. By using the data presented in this paper, the relative cost of drying with or without supplemental heat in the various localities of the country may be determined. An example has been worked out for Richmond, Virginia, during the month of June. A tabulation of the results of this analysis and the conditions assumed for it are shown in Table 1. The mean temperature and relative humidity for June at Richmond served as a basis for the computations and were considered to be the operating conditions when no supplemental heat was used. The time required to dry the given amount of hay under these conditions was computed. Based on this drying time, the amount and cost of electricity was determined. Since no supplemental heat was used, the cost of electricity was the principal operating cost and from it the operating cost per ton was determined. In like manner, the operating cost was determined for various levels of supplemental heat, the principal cost of operating being that of the electricity and oil. It will be noted that as the temperature was increased the proportionate cost of the oil became greater until at the 70 F supplemental heat level more than 95 per cent of the operating cost was that of oil. By using the conditions applicable to the various sections of the country, analysis might be made for any location. In areas where drying conditions are found to be better than those at Richmond, the comparative cost would favor drying with natural air. In other areas the reverse might well be true.

It will be noted from Table 1 that the cost per ton in drying with supplemental heat increases as the temperature is increased. This is due to the loss of heat during the later stages of drying when the air passes through the hay without picking up its full capacity of moisture. This would indicate that the lowest supplemental heat level capable of drying the hay in a reasonable time would be the most economical to use.

Operating costs alone, of course, are not the only factors determining the use of supplemental heat. The fixed cost is approximately twice as much when a supplemental heat unit is used. The quality of the hay dried will be higher if dried quickly. A previous paper (2) — Part I of this paper — indicates that a 25 F supplemental heat level might well increase the quality of hay by one-half grade. This increase is due to a greater preservation of green color and prevention of mold. Farm management practices also must be considered in determination of the need for or value of supplemental heat. The decrease in drying time when supplemental heat is used may be of considerable importance on one farm and not on another, depending in part on availablity of storage, method of harvesting, and amount of hay.

The purpose of this paper is to present a method of determining the operating characteristics of the hay driers. Three types of computations have been given as well as the basic computations and data for the general calculations. By use of the data presented herein, the time required to dry a given amount of hay, the amount of hay which can be dried in a given time and the supplemental heat level necessary to dry a given amount of hay in a given time can be determined. In all the determinations, the condition of the hay and the conditions under which it is to be dried must be known or estimated.

There are several limitations in using these data that should be understood. The observations from which these data were developed were made on chopped and long alfalfa hay only. It is hoped that more work will allow this analysis to be extended to baled hay. Analyzing the drying of hay other than alfalfa may be done by this method if the drying rate and equilibrium moisture content are known. The range of operating conditions in which data are available is limited to the temperature range of 60 to 150 F. While this range will probably cover most operating conditions, there will be some operators who wish to go above 150 F. Extrapolation of these data would serve as a guide to these operators.

These data should enable the designers of hay-drying installations to fit these installations to the farmer's needs and to advise him on the use of supplemental heat. They should enable the farmer to know more about the operation and limitations of his drier and to select the best level of supplemental heat for its operation.

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The Development and Study of the Channel-Type Terrace

By A. J. Wojta
MEMBER A.S.A.E.

THESE studies were started in 1946 with the assistance of branch station funds of the Wisconsin Agricultural Experiment Station. A cooperative project was organized a year later. The project committee is composed of A. J. Wojta and F. W. Duffee, agricultural engineering department; R. J. Muckenhirn, C. Tanner, and O. R. Zeasman, soils department; H. L. Ahlgren and R. F. Johanness, agronomy department; W. A. Rowlands and G. L. Wright, branch stations, and H. B. Atkinson and O. E. Hayes, USDA Soil Conservation Service (Research). Currently under study are the effects of the channel-type terrace system on crop yields, land drainage, machinery and machinery operations, the requirements of terrace construction machinery and the costs and maintenance of the terrace system.

The channel-type terrace as developed by Dr. Mark L. Nichols and others is the basic shape from which these drainage channel-type terraces were developed. This type of terrace was the result of improving the conventional terrace to increase the effectiveness of a terrace system as a complete surface-drainage pattern, make it possible for all field machinery to operate over the terraces, and thereby farm the entire terraced area, including plowing, rather than restricting the direction of machine travel to a series of fields many times irregular in width, bounded on either side by formidable obstacles (the terraces).

The Spencer silt loam soil area of Wisconsin, 4300 square miles in extent, was selected for these studies.

The Spencer silt loams are grey silt loams 6 to 12 in in depth and are relatively fertile. The mottled subsoil, silt pan, over compact tight gravelly clay loams is infertile and highly acid. The internal drainage is poor. Tile drains are effective for a width of one rod over the drains.

The effects of poor surface and subsurface drainage are in evidence throughout the area. The innumerable low areas (2 to 3 in in depth and from a few square feet to 2 to 3 acres in size) located within the fields collect and retain the runoff. These basins mire tillage, planting and harvesting machinery, delay the planting of spring grains, and drown out winter grains and legume seedings.

The lower portions of long 4 per cent sloped fields are unproductive as are the more level fields. The wet field conditions in the spring do not allow tillage and planting machinery on the field, and rainfall during the growing season either drowns out the crops or precludes any possibility of harvesting the crop.

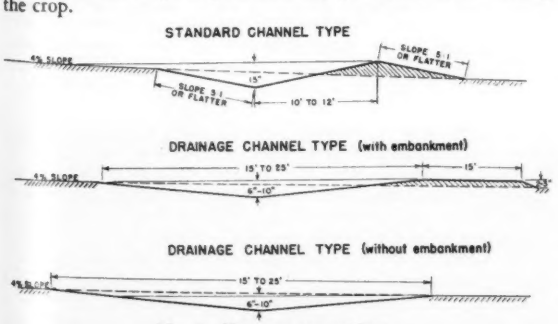

Fig. 1 Terrace cross sections

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1949, as a contribution of the Soil and Water Division.

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Fall plowing up and down the slopes to improve the surface drainage of the field has greatly accelerated soil losses. The extra large backfurrows and deadfurrows spaced 10 to 15 ft apart do not uniformly drain the field. The corrugated ground surface is difficult to farm with tractor machinery.

The standard terrace system is popular in the area, and is effective on the uniform slopes of 4 per cent or more. The Little Trappe Soil Improvement Association measured the effect of terraces on a better-drained soil series, and found that after terracing the lower portions of the slope produced more spring grain than the upper portions, while the reverse was true before terracing.

Standard terrace systems located on the more irregular and flatter slopes do improve the field drainage, but do not materially affect the low field areas located between the terraces. The raised shoulders or side banks of the waterways located on the flatter slopes actually impede the flow of runoff into the channel, as do the standard interception ditches.

Many farmers are working their terrace fields as a unit, independently of the terraces, and with the advent of the combine, forage harvester, and field baler, this practice has increased.

The most significant difference, as to terrace shape, between this type terrace and standard terraces is the fact that from 80 to 100 per cent of the water storage of the terrace is below the ground line, as compared with about 50 per cent for the standard terrace (Fig. 1). The relatively high narrow ridge or embankment of the standard terrace is easily rilled, the above-ground storage basin of the terrace is released, resulting in complete terrace failure and subsequent field damage. Furthermore, the relatively high and narrow terrace embankment is difficult to cross with all types of farm machinery, especially combines, field balers, and forage harvesters. The drainage-type terrace system differs from the conventional terrace system in other respects:

1 The terrace outlets are constructed without raised shoulders or side banks and are located in the natural field drainage ways. They are constructed as either V or flat-bottom ditches (Fig. 2).

2 The terrace sections are constructed as either V or flat-bottom ditches, 15 to 25 ft wide at the top and 6 to 10 in deep. The earth excavated from the terrace channel is used to fill all of the adjacent low areas in the field. A low (2 to 3 in high), wide (15 to 25 ft on top) terrace embankment is formed with the surplus earth (Figs. 3 and 4).

3 The terraces are located as straight and parallel as practicable, and are constructed from 5 to 8 sq ft in cross-sectional area.

4 Terrace gradients, as checked in the field, vary from 0.1 to 1.0 per cent. A uniform grade of 0.5 per cent throughout the terrace reaches is desirable.

5 The depth, height of embankment or ridge, and top width ground measurements are used to determine the final terrace cross section.

6 The area between the terraces is "finished" with a land leveler.

7 To date, studies have been confined to field slopes ranging from ¾ of one per cent to 4 per cent.

Terrace Construction. Standard terrace construction methods are designed to develop terrace capacities efficiently with the minimum movement of earth as terrace outlets are constructed with raised shoulders, formed by literally rolling the earth to either side. Terrace capacities are created by excavating earth from the channel to form an adjacent terrace embankment. Therefore, earth-moving equipment that is effective in either rolling and/or throwing earth is sufficient. This

Fig. 2 (*Upper left*) The grass waterways are located in the natural drainage ways of the field. They are wide shallow ditches constructed without raised side banks. The earth excavated from the water way is used to fill the low field areas • Fig. 3 (*Upper right*) Some of the terraces are constructed as V-shaped ditches. The earth excavated from the terrace channel is used to fill the adjacent low field areas. The excess earth forms a low terrace ridge • Fig. 4 (*Lower left*) A large tractor-scraper unit (approximately 8 cu-yd capacity) finishing a flat-bottom-shaped terrace • Fig. 5 (*Lower right*) A hydraulically controlled wheel scraper 0.85--cu-yd capacity operated by a three-plow tractor was an effective earth-moving unit

equipment ranges from motor graders, graders, and whirlwind plows to farm plows. This class of equipment is incapable of undertaking an earth-moving project that involves the haulage of earth, to predesigned standards.

The construction of the drainage-type terrace system requires that at least a portion, if not all, of the earth be moved to specified locations; hence a unit or combinations of units capable of excavation to grade, hauling, and dumping or spreading earth to specified locations are necessary.

Tractor-Scraper Units. A tractor-scraper combination is a complete excavation unit, i.e., capable of excavation to grade, hauling, dumping or spreading the earth to specified locations (Fig. 4).

Two tractor-scraper units were used to establish 10,000 lineal feet of terrace outlets located on the Marshfield and Sturgeon Bay Branch Stations. In addition, 4,000 lineal feet of terraces were constructed on the Marshfield Station.

The scraper units had a struck capacity of about 8 cu yd. The hourly rental rates were $10 and $8.60.

Standard construction methods were used to form the terraces and waterway sections.

Three-point cross sections were taken at each station (100 ft) to establish the original ground line. Final cross sections were determined by three-point (V-bottom) and four-point (flat bottom) sections. The areas of the final cross sections were computed from a level line established by the elevation of the downhill shoulder, and represent the effective area of the terrace. Earth volumes were computed by the average-end area method and represent the effective terrace volume rather than the yardage of earth excavated.

The pay-load hauling distance generally did not exceed 200 ft. The machinery costs include the hourly rental plus the moving costs.

Following is a summary of terrace costs per acre constructed with large tractor-drawn scraper units:

1 The tractor-scraper units moved about 100 cu yd of earth an hour.

2 The average unit costs per cubic yard volume of channel capacity ranged from 6 to 17 cents for waterways, or 6 to 17 cents per lineal foot.

3 Terrace capacities, without embankments, were constructed at 10 to 20 cents per cubic yard, or 3 to 6 cents per lineal foot.

4 The cost of improving one acre, including outlet cost ($1.75) on which all of the excavated material was used as a fill in the low field area, was $17. These costs do not include the "leveling" or smoothing of the entire field area. (Figs. 6 and 7).

Farm Tractor-Drawn Scraper and Land-Leveler Units. Uniform water-disposal systems were established on 60 acres of pasture land with field slopes ranging 0.75 to 4 per cent. These tracts of land, averaging about 10 acres each, were located on the Marshfield Branch Station and five private farms.

A combination of a hydraulically controlled wheel scraper and a land leveler were used to establish these systems. These machines, with the exception of those used on the ten-acre tract located on the Marshfield Station, were powered with privately owned 2-plow (land leveler) and 3-plow (wheel scraper) tractors, and operated, for the most part by farm operators.

A hydraulically controlled wheel scraper (0.85 cu-yd average capacity) with a cutting blade 42-in wide was used (Fig. 5). Two double-acting cylinders located on either side of the bucket actuated the cutting, hauling, and dumping position of the bucket. The two rear scraper wheels were located to the rear and within the cutting width of the blade.

A double-stylus recorder mounted to the scraper frame recorded the actual moving time and the number of scraper dumps on a 6-in chart, driven by a spring-wound clock motor. The chart made one revolution in 4 hr. The actual moving time was recorded by a stylus mounted on a pendulum that oscillated with movement of the scraper. The oscillations were recorded as a wide line on the chart.

A six-volt relay powered by the tractor battery was operated by a mercury switch attached to one side arm of the bucket. The switch made contact when the bucket was tilted back-

ward to the dumping position, causing the stylus to record a dash on the chart.

The land leveler consists of a frame that supports a V-shaped non-cutting blade, a cutting blade 6 ft wide, and a rear leveling fin (Fig. 6). When the unit is used as a leveler, the ground wheels actuate the cutting blade through a crank-shaped axle. As the ground wheels "drop" into field depressions, the blade is raised, thereby depositing the earth dragged by the blade. The ground wheels traveling over "high spots" lower the cutting blade. The leveler was used as a leveler and as a scraper to level the area between the terraces and finish the terraces and terrace outlets.

A single-stylus recorder with an oscillating stylus recorded the actual moving time of the leveler.

Following is a summary of terrace costs per acre constructed with farm tractor-drawn scraper and land leveler units:

1 The data showed that from 1½ to 2½ scraper hours or from 62 to 90 cu yd of earth were moved to improve one acre, and in addition one to two hours of leveler time was needed. Assuming a machinery rental cost of 50c per hr (original cost of each machine about $400) for each machine, tractor operating cost of 75c per hr (daily gas consumption 10 to 18 gal), tractor operator at 75c per hr and allowing 33 per cent for lost time, the cost per acre would range from $7 to $12. This data is based on 82.66 hr actual moving time of the scraper, 3613 scraper dumps, and 55.04 land-leveler hours.

2 The scraper dumps ranged from 26 to 63 or 22 to 53 cu yd per hr, with an average of 37 cu yd per hr. The average pay haul distance in most cases did not exceed 150 ft, but averaged 30 to 40 ft. The scraper constructed 177 lineal feet of terrace per hour. Subsequent field observations indicated that, on terrace sites not requiring all of the earth to be moved, the production (lineal feet of terrace) of the scraper could easily be double or trebled if plows were used to construct the terrace ridge. In these cases the scraper established the terrace grade, moved the necessary earth into the field depressions, and later served as a finishing machine.

A comparison of initial ground survey, based on one-point cross section, and final survey (40-point cross sections taken every 100 ft), showed that from 80 to 100 per cent of the storage capacities of the constructed terraces were located below the original ground line.

Effect of Tillage Practices upon the Reduction in Terrace Capacities. Observations and trial-and-error methods indicated that farm machinery will give satisfactory performance over flat-bottom or V-shaped sections for terrace depths of 6 to 12 in; side slopes of at least 6 to 1, and preferably 10 to 1, are desirable for machinery operating safely over the terrace at normal field-operating speeds (Fig. 7).

To date, 5,000 ft of terraces located on an average field slope of 3 per cent have been studied for three consecutive seasons. The sections under study include a flat-bottom-shaped terrace with a bottom width of 8.0 ft, side slopes of 6 to 1 with depths ranging from 4 in to 2 ft and two V-shaped sections, with side slopes of 6 to 1 and 10 to 1 with depths ranging from 0.6 to 1 ft.

Ground measurements were established from 3 to 20-point cross sections taken every half station (50 ft). The cross section locations are established from a measured base line. The terrace cross-sectional area was computed from a level line established at the elevation of the downhill shoulder and represents the effective terrace area. The plotted area was measured with a planimeter.

Tillage and cultural practices necessary for the production of corn, grain and sod crops were performed over the terraces (Fig. 8). The practices including plowing, disking, harrowing, corn cultivation, and field cultivation necessary to control quack grass.

SUMMARY

Although the statistical analysis of this data is not completed, and more field information is needed, definite trends are indicated.

1 A deadfurrow or single furrow practically destroys the entire terrace capacity.

2 Flat-bottom-shaped terraces, i.e., bottom widths 8.0 ft, side slopes 6 to 1 constructed to *(Continued on page 231)*

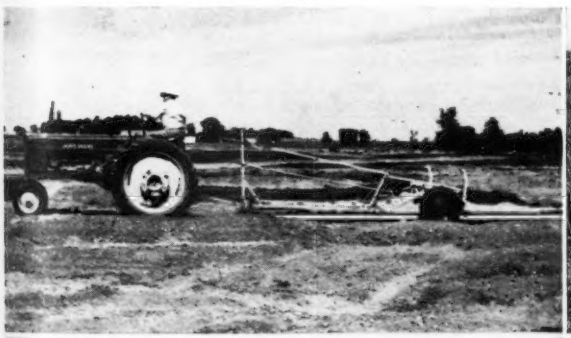

Fig. 6 (*Upper left*) The area between the terraces is smoothed and the terrace is shaped with a land leveler, preferably during the fall season • Fig. 7 (*Upper right*) Machinery operations were independent of the terraces • Fig. 8 (*Lower left*) The combine was operated over the terraces • Fig. 9 (*Lower right*) A uniform water-disposal system provides for a complete surface drainage pattern, controls erosion, and allows the operation of all field machinery over the terraces; hence, larger fields, better machine performance and increased yields of grain and hay on Spencer silt loam soils

A Proposed Standard Short Tongue Farm Wagon

By Sherman C. Heth
MEMBER A.S.A.E.

AS WITH most proposals for a standard, this one originated because two separate components would not fit together.

For general farm hauling work, any wheeled device with a box will serve, providing it is reasonably sturdy and well made. However, when farm wagons are used as accumulators for harvested materials, while being pulled behind various pieces of farm equipment, problems of turning, top and end clearances, and widths, all become quite pertinent. Frequently the farmer is confronted with a situation where two pieces of equipment occupy or attempt to occupy, the same space at the same time.

The designer and the manufacturer of harvesting machines, intended to operate in conjunction with short-tongue farm wagons, are confronted with the problem of providing hitches, clearances, etc., which will permit use of the wagon equipment in the hands of the user. The designer and manufacturer of short-tongue farm wagons is certainly confronted with the problem of adapting such equipment to various harvesting machines.

That which is proposed here is offered as a starting point, something on which to make a beginning. I hope that the ASAE will appoint a committee of qualified industry representatives to consider this problem and to come up with a proposal acceptable to all major factors in the industry, for adoption as an ASAE standard.

Now for some of the various points to be considered in arriving at dimensions which would fit the majority of applications. Fig. 1 shows, in outline, four elevators, hitch points, and wagon tongue lengths, from front of box, of mounted corn picker elevators and wagons built by major manufacturers of such equipment. The elevators and hitch points illustrated are approximately to scale. The F, G, H and I dimensions for tongue hitch to wagon box all varied, some substantially. Dimension X for height of box above ground line also varied considerably.

Fig. 2 shows, in outline, four pull-type corn picker elevators and hitch points for pull-behind wagon arrangements. The same factors for tongue hitch to front of box, and for box height, as described in connection with Fig. 1, also apply. On corn pickers of this type, the variable from centerline of picker wheels to picker-wagon hitch points is relatively small on three machines.

Fig. 3 shows field forage harvesters. The harvester centerline of wheel to harvester-wagon hitch points was quite close on the three units considered. The height and length of discharge spouts varied considerably, however, which certainly creates quite a problem for the customer purchasing a "closed" wagon for handling field-chopped grains.

Fig. 4 shows a composite mounted corn picker with tentative figures for hitch point from centerline of tractor wheel to centerline of wagon hitch, wagon hitch to front of box, and

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 1949, as a contribution of the Power and Machinery Division.

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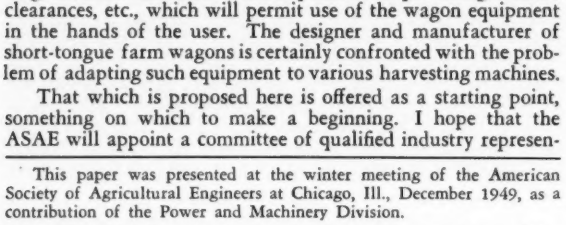

Fig. 1 Mounted corn pickers

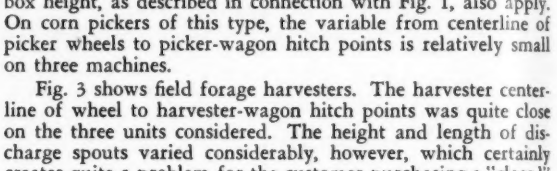

Fig. 2 Pull-type corn pickers

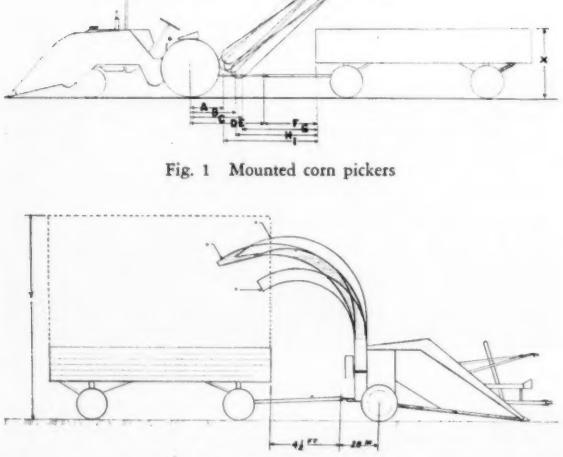

Fig. 3 Forage harvesters

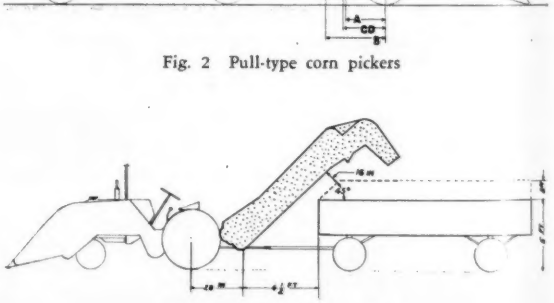

Fig. 4 Mounted corn picker

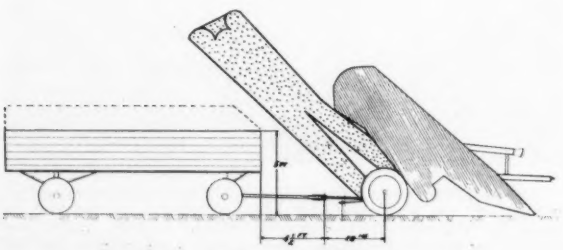

Fig. 5 Pull-type corn picker

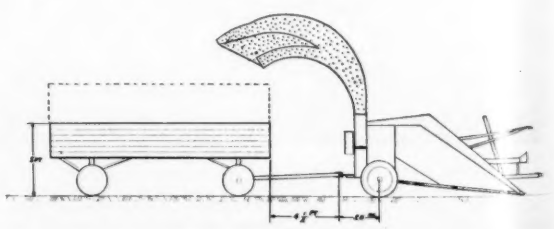

Fig. 6 Forage harvester

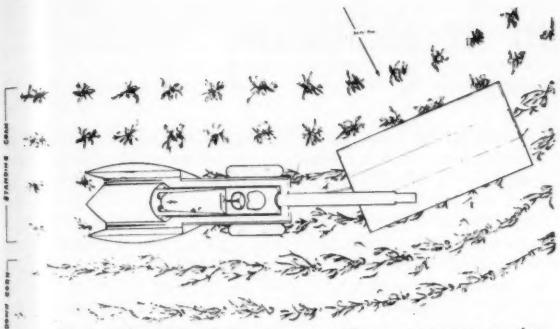

Fig. 7 Plan view of two-row corn picker on contour operation

box and extension heights. Due to turn factors, a relatively uniform figure from tractor wheel centerline to centerline of wagon hitch point is desirable. Possibly the mounted harvesting equipment engineer could assume responsibility for providing a suitable hitch point. This is offered as a suggestion for consideration, in the event that variables in tractor drawbar and tractor wheel centerline relationships should prove to be too much of an obstacle.

Fig. 5 shows a composite pull-type corn picker, with rear hitch for wagon. On both the mounted and pull-type corn pickers, it is my opinion that the picker engineer will have to continue to mount elevators so they can rise if the ground contour causes the front of the wagon box to strike the underside of the elevator.

Fig. 6 shows a composite field forage harvester. No figure for a closed box is indicated as this factor is hardly one to consider in connection with standardized wagon. It could well be considered the subject of a supplementary study.

Fig. 7 shows a mounted corn picker and pull-behind wagon operating in a contoured corn field. This was included in this paper to illustrate the need for an approximately uniform figure for centerline of tractor wheel to centerline of wagon hitch point. If this is done, wagon designers will be able to establish their tongue-controlled steering gears for optimum trailing effect, both to avoid running into unharvested crops and to maintain beds under fixed crop discharge points, as far as is practical.

Fig. 8 shows an end view of the three most common types of boxes. In order to obtain certain desirable features, I recommend consideration of a 7-ft width, or flareboards to achieve this width. The desirable features of the 7-ft width are (1) that it has a low center of gravity, (2) that this width will operate quite well between generally accepted corn row plantings, (3) that the bed is kept under the elevator discharge points fairly well on contour operations, and (4) that it is suitable for highway transport purposes.

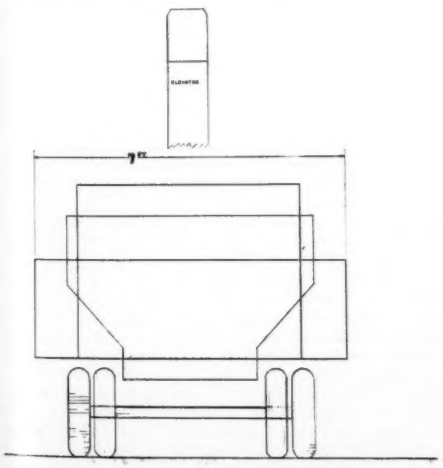

Fig. 8 End view of wagons

All of us who have had occasion to be in the field with harvesting machinery and pull-wagon combinations know how annoying and time consuming the hookup problems can be. We have an opportunity to perform a very real and valuable service to the farmer if we can provide a standard which, if complied with, will enable the user to connect wagons to harvesting machines without preliminary carpentry and blacksmithing work.

Channel-Type Terrace

(Continued from page 229)

depths ranging from 0.5 to 1.0 ft, showed that the change in end area, resulting from all tillage operations for one season, ordinarily needed to produce corn and small grain, was no greater between the terrace depths than within each depth. The depths were segregated by 0.1-ft intervals. The average per cent change in terrace capacity for all depths was 3 per cent reduction and ranged from 18 per cent increase to 14 per cent decrease.

3 The V-section terrace with 10 to 1 side slopes most nearly approximates the parabolic-shaped section that results from tillage operations over the terrace.

Improvement in Land Drainage and Crop Yields. The economic benefits derived from the improvement in land drainage were observed in 1947, a normal season, and are being studied under the supervision of the soils and agronomy departments for the past two seasons (Fig. 9). The total precipitation for the past two seasons (1948 and 1949) was, respectively, 8.5 and 4.1 in below the normal rainfall.

A two-acre field depression located in an otherwise good cropping field that had previously produced soybeans, buckwheat, and sometimes corn before treatment, after fall treatment in 1947 was the first field on the entire station to dry up sufficiently to plant to grain about two weeks before the adjoining land that had been fall plowed up and down the slope. This area after being fertilized and planted to Forvic oats outyielded all of the other oat fields on the station, 93 bu per acre.

A 10-acre tract located on the lower portion of a long field slope (3 per cent) that had not been plowed for six years because of poor drainage. After a fall treatment in 1948 it was the first field to dry up in the spring and yielded 77 bu per acre, the highest field yield of oats on the station. The field at present is supporting an excellent stand of mixed legumes. The three-acre check produced no oat crop.

A comparison between leveled and terraced land and leveled land, located on a cropland field (3 per cent—80-rod long field slope), for the years 1948 and 1949, showed a yield increase of 6 bu of oats in favor of the terraced and leveled area. Legume counts taken from the first year hay crop showed that the production of legumes from the treated area is doubled. The total forage production was 50 per cent greater from the treated area as compared with the untreated area.

Data obtained from gypsum blocks for one season, 1949, indicates that ground water collects in the terrace channel during the corn growing season.

CONCLUSIONS

A terrace drainage system can be constructed on field slopes ranging from 0.75 per cent to 4 per cent that will serve as an effective drainage system, and permit tillage and harvesting equipment to operate independently of the terraces without excessive terrace maintenance, providing the deadfurrows located across the terraces are obliterated immediately after plowing. The terraces should be built up at least once during the rotation.

The cost of constructing the system ranges from $7 to $17 an acre. The use of farm-tractor-powered equipment, farm operated, will reduce installation costs by at least 50 per cent.

A combination of excavating equipment, i.e., plows and scrapers, is more efficient in the installation of the system than is a single unit such as the wheel scraper. The addition of a complete excavation unit in combination with presenting terracing equipment is highly desirable. *(Continued on page 233)*

ECPD Curriculum Accreditation

By J. D. Long

THERE are several phases and implications, of special interest to agricultural engineers, in the curriculum accreditation program of the Engineers Council for Professional Development (ECPD).

The primary purpose of the program is to insure that engineering curriculums are deserving of that designation. Any curriculum designated as engineering should be subject to accreditation under this program. It is obvious, therefore, that it applies only to the professoinal agricultural engineering curriculums; those curriculums offered by agricultural engineering departments but designed for students majoring in agriculture are not included. It will avoid confusion if departments offering the latter type of curriculums will conform to the resolution adopted by the Association of Land-Grant College and Universities in 1948 and designate them as "mechanized agriculture", or by some similar terminology other than agricultural engineering.

Since the program applies to engineering, it is implied that the professional agricultural engineering curriculum must be administered by the dean of the college of engineering, or jointly by him and the dean of the college of agriculture. The first agricultural engineering curriculums were developed and have operated harmoniously under joint administration. Such administration applies only to the professional agricultural engineering curriculum in those institutions and includes only the agreement of the two deans on selection of faculty for the professional curriculum, the courses included in the curriculum, and the content of those courses. It does not usually include the department budget or research program which are administered under the college of agriculture. With the growing interest in engineering research in academic institutions, it might well prove a benefit if agricultural engineering research were also under the joint administration.

Since the request for ECPD inspection is usually issued by the president of the institution at the recommendation of the dean of engineering, it is only being realistic to anticipate that he will make such recommendation only if he exercises some administrative responsibility for the curriculum. Sharing the responsibility does not mean that the agricultural dean is losing control or that the agricultural engineering students will be any less vitally interested in agriculture. It is recognized that agricultural engineering occupies too strong a position in agriculture and is too concerned with the industry it serves to willingly sacrifice this relationship. There can be no question, however, that students in this field will be best prepared to meet their responsibilities in the agricultural industry if they are properly conditioned academically as agricultural engineers.

The accreditation program is specifically concerned (1) that the professional agricultural engineering curriculum faculty are qualified to teach their subjects as engineering courses; (2) that the subject matter in these courses is treated as engineering technology and is based on pertinent fundamental engineering courses, and (3) that the facilities are adequate for engineering instruction in each subject.

The accreditation program specifically states that it does not attempt to standardize engineering education and that no "score card" has been published for this reason. Establishing a reasonable degree of standardization in the curriculum course content beyond the essential engineering fundamentals is a logical function of the professional engineering society interested in each different engineering curriculum and should be reached voluntarily. Due allowances are available, therefore, for meeting specialized regional requirements.

Making a request for ECPD inspection carries the obligation of meeting a standard fee for ECPD and inspection committee expense.

Upon receipt of such a request the ECPD secures general information by means of a questionnaire, and, if this is satisfactory, arranges for a personal inspection by a regional subcommittee. This subcommittee, which is usually formed to inspect several engineering curriculums during their visit to the institution, is composed of one engineer for each professional curriculum to be inspected. The agricultural engineers nominated by ASAE to serve on these regional subcommittees have no formal responsibility to our Society but serve on call by ECPD. The qualifications considered in nominating them were: (a) graduation from an agricultural engineering curriculum, (b) member of ASAE and with a record of professional accomplishment which extends beyond state boundaries, and (c) personal interest in agricultural engineering education. The men comprising this group serve for an indefinite period.

It should be noted in the accompanying statement of accrediting procedure that the visiting committee reports its findings to the ECPD regional committee, that these are then passed to the ECPD Committee on Engineering Schools and thence to the main body of ECPD. Each of the three reviewing bodies may require additional information or reverse the previous recommendations.

It may be of interest to note that the membership of ECPD is comprised of the following professional engineering organizations: American Institute of Chemical Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, American Society for Engineering Education, National Council of State Boards of Engineering Examiners, and Engineering Institute of Canada.

In conclusion, it may be stated that there are obvious advantages in preparing a department of agricultural engineering for the inspection of its curriculum and in receiving an impartial evaluation of its work. Accrediting inspires confidence in both faculty and students and generates a greater professional consciousness. Graduation from an accredited curriculum is an important factor in the registration of professional engineers, and may be specified in the future for certain membership grades of professional engineering societies. It will almost certainly become a factor, also, in the future engineering recruitment policies of academic institutions, of other public service agencies, and of engineering industry employers.

Following is a statement of the objectives and procedure in the work of accrediting undergraduate engineering curriculums, from the ECPD 17th Annual Report:

Organization and Objectives. The Engineers' Council for Professional Development has as its expressed objective the enhancement of the status of the engineering profession. To this end the Council inaugurated in 1932 a program dealing with the selection, guidance, training, and recognition of the members of the profession. The program is being carried out under the direction of four operating committees. The initial objective of one of these, the Committee on Engineering Schools, was, as part of its broad purpose of assisting in the improvement of the status of engineering education, "to formulate criteria for colleges of engineering which will insure to their graduates a sound educational background for practicing the engineering profession."

At the time the committee was constituted there was danger of a multiplicity of accredited lists and accrediting agencies, largely from the uncoordinated efforts of more than 30 states whose laws provided for the licensing of "professional engineers." No one list was accepted on a national basis, nor could there be any assurance of a country-wide uniformity of high standards. There was potential danger not only that the accredited lists would be subject to political manipulation, but that accrediting might become so inflexible as to discourage intelligent experimentation. Furthermore, an increasing number of states were requiring the registration of engineers. One of the major purposes of the ECPD was the amelioration of these unsatisfactory conditions regarding accrediting. This task became the function of the Committee on Engineering Schools.

The wide acceptance of the committee's list by organizations such as the National Bureau of Engineering Registration, the National Council of State Boards of Engineering Examiners, by nearly all of the individual state boards, by the professional engineering societies, several

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of the bureaus of the United States Government, and the institutions themselves, is gratifying evidence of the cooperation and respect of the institutions and organizations concerned.

Basic Policies. Through continuing and careful study of the problems of accrediting, the committee has evolved and adhered to the following basic policies:

1 The accrediting of curricula rather than institutions, for it is well recognized that curricula of quite different standards may sometimes be found at the same institution.

2 The consideration for accrediting of undergraduate curricula only, with the appraisal of graduate curricula deferred to permit adequate attention to the far more urgent undergraduate problem.

3 The invitation to institutions to submit curricula without persuasion or pressure brought to bear by the committee.

4 The avoidance of rigid standards as a basis for accrediting, in order to prevent standardization and ossification of engineering education and to encourage well-planned experimentation.

5 As a safeguard to the public and without setting any rigid standards, the nonaccrediting of curricula which omit a significant portion of a subject in which the public may reasonably expect engineers of that field to have competence.

6 The careful consideration of qualitative as well as quantitative factors through a visit of inspection by a competent committee of engineers and engineering educators.

7 The review of the findings and recommendations of the inspection committee, in turn by the appropriate regional committee, by the Committee on Engineering Schools, and finally by ECPD.

8 The publication of a list of accredited curricula only, with no information available to any person (other than proper officials of an institution concerned) as to whether an institution not on the accredited list had been turned down or had not submitted its curricula for accrediting.

Accrediting Procedure. Consideration of curricula with a view toward accrediting is done at the invitation of the institution.

An institution desiring accrediting of any or all of its undergraduate curricula that lead to degrees in engineering may communicate directly with the ECPD Committee on Engineering Schools. Arrangements will then be made for securing information by questionnaire and for an inspection of the educational facilities of the institution by a regional subcommittee.

Each committee of inspection is selected, on the basis of the curricula to be considered, from the membership of the regional committee operating in the area in which the institution is located. The visiting committee reports its findings to the regional committee which, after consideration of all available information, submits to the Committee on Engineering Schools a set of tentative recommendations. Final decision as to accrediting rests with ECPD, which passes on the recommendations made to it by the Committee on Engineering Schools.

Basis for Accrediting Engineering Colleges. The following statement, proposed by the Committee on Engineering Schools and approved by Council and by the constituent member organizations, embodies the principles in accordance with which accrediting is conducted.

I Purpose of accrediting shall be to identify those institutions which offer professional curricula in engineering worthy of recognition as such

II Accrediting shall apply only to those curricula which lead to degrees

III Both undergraduate and graduate curricula shall be accredited. (Accrediting program at present embraces undergraduate curricula only.)

IV Curricula in each institution shall be accredited individually. For this purpose, ECPD will recognize the six major curricula—chemical, civil, electrical, mechanical, metallurgical, and mining engineering—represented in its own organization, and such other curricula as are warranted by the education and industrial conditions pertaining to them.

V Curricula shall be accredited on the basis of both qualitative and quantitative criteria.

VI Qualitative criteria shall be evaluated through visits of inspection by a committee or committees of qualified individuals representing ECPD.

VII Quantitative criteria shall be evaluated through data secured from catalogs and other publications, and from questionnaires.

VIII Qualitative criteria shall include the following:
- (1) Qualifications, experience, intellectual interests, attainments, and professional productivity of members of the faculty
- (2) Standards and quality of instruction:
  - (*a*) In the engineering departments.
  - (*b*) In the scientific and other co-operating departments in which engineering students receive instruction.
- (3) Scholastic work of students.
- (4) Records of graduates both in graduate study and in practice.
- (5) Attitude and policy of administration toward its engineering division and toward teaching, research, and scholarly production.

IX Quantitative criteria shall include the following:
- (1) Auspices, control, and organization of the institution and of the engineering division.
- (2) Curricula offered and degrees conferred.
- (3) Age of the institution and of the individual curricula.
- (4) Basis of and requirements for admission of students.
- (5) Number of students enrolled:
  - (*a*) In the engineering college or division as a whole.
  - (*b*) In the individual curricula.
- (6) Graduation requirements.
- (7) Teaching staff and teaching loads.
- (8) Physical facilities—the educational plant devoted to engineering education.
- (9) Finances: investments, expenditures, sources of income.

Information supplied by means of the questionnaire, or otherwise, is for the confidential use of the ECPD and its agents and will not be disclosed without the specific written authorization of the institution concerned.

Scope of Accredited List. ECPD is merely authorized by its constituent organizations to publish a list of accredited engineering curricula for use as desired by those agencies which require such a list. It has no authority to impose any restrictions or standardizations upon engineering colleges, nor does it desire to do so. On the contrary it aims to preserve the independence of action of individual institutions and to promote thereby the general advancement of engineering education.

This list includes only such undergraduate engineering curricula as have been judged by ECPD to be worthy of accrediting. It does not include certain specialized curricula submitted for consideration which, though apparently outstanding in restricted fields, are not closely related to engineering as it is interpreted by ECPD.

In some cases accrediting has been made provisional for a limited period (from one to three years), with reappraisal stipulated at the end of the period. The provisional nature of the accrediting is based upon conditions which ECPD has found not to be entirely satisfactory, but which may be quickly improved, or conditions which are now satisfactory but of which the future appears precarious. Such conditions include the following: uncertainty as to financial status; need for minor additions to staff or equipment; curriculum new or in state of transition; uncertainty due to nature of administrative organization; unusual dependence upon strength of a single individual. In every case where term accrediting has been granted, the institution has indicated that an effort will be made to remedy the unsatisfactory condition within the stipulated period of accrediting. The fact that accrediting may be thus provisional is, in each case, confidential with ECPD.

The present listing dating from October 28, 1949, will again be subject to revision in the fall of 1950. (NOTE: Currently ECPD accredited professional agricultural engineering curriculums are offered by the University of California, Iowa State College, Kansas State College, University of Nebraska, and Oregon State College.)

Advisory Service. Incident to the accrediting program, and only upon request of recognized officials of an institution, the committee has given informal advice on matters such as changes in educational policy, in organization, in curricula, personnel, and physical facilities. This has proved an important phase of the committee's work in advancing engineering education.

Provision for Reinspection and Review. The list of curricula which have been accredited by ECPD is to be revised annually. Through its Committee on Engineering Schools ECPD will keep currently informed of significant changes in curricula, staff, facilities, organization, enrollment, et cetera, in institutions where curricula have been accredited, and will arrange to have certain institutions revisited each year.

In order to maintain the accredited list on a dependable and up-to-date basis a program of reinspection of curricula, initially accredited three to five years before, was begun in 1940. It was planned that every three to five years each institution on the accredited list would be revisited to ascertain changes since the first inspection which might affect the accredited curricula. Because of the demands upon the time of committee members, and lowered student registrations during the war, it was necessary to curtail this program. The original program of periodic reinspections was resumed in the fall of 1947.

Requests for further information relative to ECPD and the accrediting program may be addressed to the Secretary, Engineers' Council for Professional Development, 29 West 39th Street, New York 18, N. Y.

Channel-Type Terrace

(Continued from page 231)

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Operation and Performance of Alfalfa Dehydrators in the Central United States

By Leonard G. Schoenleber
MEMBER A.S.A.E.

DEHYDRATION of alfalfa makes possible the preservation of a high percentage of the nutrients through harvesting at the proper stage of maturity and fast drying, and by minimizing the hazards of weather. Alfalfa made into meal makes a valuable ingredient in mixed feeds for poultry and livestock.

The production of dehydrated meal in the United States has increased from 245,400 tons in 1943 to 728,300 tons in 1948. This is approximately two per cent of the total alfalfa production of the United States. The yearly price average of 17 per cent protein dehydrated alfalfa meal at the Kansas City market from 1938 to 1948 ranged from $26.65 to $60.40 per ton. During this period, the yearly price average of 17 per cent protein meal ranged from $13 to $33 more per ton than No. 1 baled alfalfa and from $6 to $18 more per ton than ground sun-cured hay at the Kansas City market.

It is estimated that there are more than 500 alfalfa dehydration plants in the United States. Of these plants, more than 35 per cent are located in Kansas, Nebraska, and Colorado. The following information was obtained in 1949 from 44 dehydrating plants located in these three states. The plants included some of the smallest as well as the largest companies.

Investment in Plants. The investment cost of the plants varied considerably, ranging from $40,000 to $190,000, for each drying drum installed. The average investment for 16 plants of one-drum unit size was $95,000, while that for 16 plants of two-drum unit size averaged $150,000. This included the cost of field machines, trucks, trailers, plant equipment, buildings, and installation costs. Building costs and auxiliary equipment, such as pellet machines, meal-cooling equipment, dust reclaimers, sifters, blenders, sack-packer attachments, shredders, and self-propelled field harvesters, account for much of the variation of investment costs.

Many operators consider a minimum cash reserve of $10,000 to $15,000 necessary at the start of a dehydration season to meet expenses. If meal is stored instead of sold, or if more than one drum per plant is used, even larger cash reserves are needed.

Equipment and Plant Layout. All of the dehydration plants surveyed in the three states have drum-type driers. The majority of the drums are rated with capacities to evaporate 6,000 lb of water per hour. The others have rated capacities of evaporating 12,000 lb water per hour. The drums vary in size and are either single or multiple-pass type. Single-pass drums vary from 8 to 10 ft in diameter and from 28 to 40 ft long. The multiple-pass drums are 8 ft in diameter and 24 ft long. The majority of the drums are of manufacturers' design. A few of the manufactured drums are modified to suit the owner. Other drums are entirely of the owners' design and are the single-pass type.

Plant installations consist of drying units of one, two, or three drums. Many operators feel that a two-drum plant is more economical to operate than a one-drum plant.

There is no one arrangement of equipment used by all the plants. Convenient and accessible space is provided at the plant for trucks or trailers transporting the forage from the field to the feeder of the dehydrator. The warehouses and sacking rooms are usually located next to the railroad siding to facilitate loading of box cars. The equipment of the plant is usually arranged to meet the desire of the plant owner or to meet some particular problem.

At many of the plants a concrete slab is provided in the working areas. This makes working conditions more agreeable with less dust and rough ground to contend with and makes it much easier to clean up around the plant.

Automatic feeder equipment has replaced hand feeding of dehydrators almost 100 per cent. Although several different designs of automatic feeders are in use, the principle of operation is essentially the same. Each type feeder has a large hopper to hold the green forage. A conveyor chain in the bottom of the hopper and a leveling device meter the forage automatically to a conveyor system which feeds into the drying drum.

Wherever natural gas is available in large amounts and at low rates, it is used as fuel to dry the forage. Approximately 90 per cent of the plants use natural gas. The others use fuel oil.

Large amounts of power are required to operate a dehydration plant. Electric motors are well adapted to this use and are used almost universally to power the machines. The connected electrical load for each drying drum unit ranges from 130 to 350 hp, depending on the amount and size of equipment used. Grinders require the most power and are usually powered with either 125 or 150-hp motors.

A majority of the plants have tube-type furnaces. The tubes are lined with fire brick or clay and range in length from 9 to 16 ft and in diameter from 3 to 4 ft. The heat absorbed by the tube furnace is less than for larger furnaces and consequently heat losses are less during periods when the plant is shut down.

The average size plot of land used for the dehydration plants surveyed is 2.5 acres. The smallest plot of land is 0.5 and 0.7 acres, respectively, for one-drum and two-drum plants. The owners expressed the opinion that such space is adequate except when all of the field machines and equipment are stored during the winter months. The arrangement of the plant equipment will determine to a large extent how much space is needed for convenient operation.

The building storage space for meal at the various dehydration plants varied from 15 tons to more than 3,500 tons capacity.

The number of years the plants have been in use ranged from 1 to 10 with an average of 4.

Owners of small plants have as the very minimum the following equipment:

1 drying drum with furnace, burners, and power unit
1 automatic forage feeder with conveyor to drum and power unit
2 cyclones
1 hammer mill and power unit
1 sacking spout.
Conveyors, piping, blowers, and motors to carry dried forage to the cyclones and sacker spout
1 scale (for weighing 100-lb sacks of meal)
3 trucks, or 2 trucks and 4 trailers
1 self-propelled field harvester, or 1 tractor and field harvester with cutter attachment
Uploading hoist or truck equipment with hydraulic lifts
Shop repair tools and equipment
Sacking and storage building.

It is also advisable to have spare parts, such as sickle parts and grinder hammers and screens, as well as some duplicate equipment for replacement of machines subject to excessive wear or frequent breakdowns, such as field harvesters, trucks, and tractors.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author: LEONARD G. SCHOENLEBER, agricultural engineer, division of farm electrification (BPISAE), U. S. Department of Agriculture, Beltsville, Md.

Plants with more elaborate equipment may include any one or all of the following items: dust collectors for reducing the dust around the plant and for retaining a larger percentage of the alfalfa, pellet equipment, cooling equipment, sifters, packers, crushers, and self-unloading trailer attached to field chopper.

Operation. The operation of a typical dehydration plant is as follows: Alfalfa is cut, chopped, and blown into trucks or trailers with a field chopper. It is then transported to and dumped into the automatic feeder of the dehydrator. The feeder conveys the chopped alfalfa to the drying drum; from the drum the dried forage is conveyed through one or more cooling cyclones to a hammer mill, then through one or more cyclones for further cooling, and to a sacking attachment. The dried alfalfa is conveyed by means of a system of pipes with fans through the cooling cyclones, hammer mill, and sacking attachment.

When meal is sifted, it is done just before sacking.

If the meal is to be pelleted, it is treated with steam or water spray as needed for a binding agent, then run through a pellet machine. Since the temperature of the dried alfalfa is raised during the pelleting process, it is run through a cooling chamber. The pellets enter the top of the cooling chamber and are drawn off the bottom in a continuous stream. Any fine meal found with the pellets is usually screened out and passed through the pellet machine.

Blending meal to obtain a desired protein and carotene analysis is usually a separate operation. However, several operators reported blending of two meals during the dehydration process. This is accomplished by use of a screw-type feeder that meters meal into the air stream at the hammer mill. The meal is mixed thoroughly and requires very little equipment. It is necessary, however, to know the analysis of the alfalfa as it is dried, as well as of the added meal, in order to mix the correct proportions for obtaining a desired analysis.

Crushers are sometimes used to reduce the chopped green forage to a small uniform size to promote faster and more uniform drying. This equipment, when used, is placed between the automatic feeder and drum.

Most of the operators prefer to cut alfalfa at early or preboom stage when the nutrient values are highest.

The dehydration season extends over a period of 5 to 6 mo. The season starts around May 1 and runs until frost. Four to six cuttings of alfalfa are made per season, depending on the growing season. Alfalfa not irrigated averages from 3 to 5 tons per acre per growing season. That which is surface irrigated or subirrigated averages from 4 to 7 tons per growing season and provides a more dependable source of forage, as it is less dependent on moisture from rain.

Because alfalfa varies in quality between cuttings and most growers prefer to sell by cutting, the majority of the dehydration plant operators contract for alfalfa by cuttings. The acreage needed to provide alfalfa for each drum of a dehydration plant varies with the cuttings, depending on the growth of alfalfa. Some operators require over twice the acreage needed by others to operate a dehydrator, depending on the efficiency of plant operation and rate of drying. The average of all plants was 550, 600, 800, and 950 acres, respectively, for the 1st, 2nd, 3rd, and 4th cuttings.

The farthest distance the green forage was hauled averaged 11 miles for all of the plants surveyed. Three operators reported a maximum hauling distance of 25 miles, although this is not the usual practice.

The estimated production of meal for 1949 averaged 2,470 tons per drying drum. The highest production was 5,000 tons of meal from one drum which had a capacity to evaporate 12,000 lb of water per hour.

Two to four men are usually employed during the winter months to overhaul and repair all plant and field equipment.

Some plants are used to grind limited amounts of sun-cured hay during the winter months to help pay for fixed charges on the plant, and also to keep the most competent help the year around. Sun-cured hay is either ground at the stack, in the field with a hammer mill, or at the dehydration plant. If the sun-cured hay has excessive moisture content, the grinder capacity is greatly reduced. Many operators will chop such hay and run it through the dehydrator drying drum before grinding. The temperature of the drum is kept low to prevent overdrying and burning.

Fields in areas having irrigation ditches are harvested in small plots as the harvesting equipment will not operate satisfactorily over the ditches. Operating the harvesting equipment on the small plots requires much turning and loss of time.

At nights and during periods of high humidity, forage has high moisture content and requires more fuel to remove the desired moisture than during the daytime at periods of low humidity. Several operators reported drum temperatures as high as 2,000 F during the night, when forage is wet and the humidity high. During the daytime, as the drying conditions become more favorable, the drum temperatures may be reduced to as low as 1,000 F, which require one-half the amount of fuel used during the night. The outlet temperatures ranged between 250 and 325 F, depending on the moisture content of the green hay and the feed rate. At higher outlet temperatures the meal is easily scorched.

Most operators agreed that a higher quality meal is produced when the output of the drier is run below rated capacity. Scorching is often experienced when meal is dried to below 6 or 8 per cent moisture content. Meal containing 12 per cent moisture content or more reduces the hammer mill capacity materially.

Many operators expressed the opinion that plant production is limited to the capacity of the hammer mill or pellet machine and not that of the drying drum.

Labor Requirements. The majority of the dehydration plants operate with two 12-hr shifts. The crews alternate between day and night work every two weeks. Some plants shut down 12 hrs, others 24 hrs, once every two weeks when the day and night crews change working hours.

The average size crew, exclusive of office help or manager, was 7, 11, and 15 men, respectively, for one, two, and three-drum plants. A typical seven-man crew may consist of one mill operator and feeder, two sackers and storage operators, one field operator, two haulers, and one repair man. When yields are light, it may be necessary to operate two field choppers. For very short hauls, only one man may be needed.

At times when there is not enough alfalfa for continuous dehydration, only one drum (should the plant have more than one drum) or only a daytime crew may be used. If the crop has matured, the plant may be run continuously until the hay is all dried; then the plant is shut down until later crops are available.

When sun-cured hay is ground into meal during the winter months, a crew of up to 10 men may be used for a period of 8 or 10 hr per day.

Cost of Production. The total cost of producing a ton of dehydrated alfalfa (including payment for the crop, labor, management, office personnel, bags, repairs, taxes, interest and depreciation on investment) varied in 1949 from $27 to $44.50 and averaged $37, according to estimates from 33 plants. Several operators expressed the opinion that the cost was a little less than the previous year.

Direct labor costs in processing alfalfa vary considerably among plants, depending on the equipment used as well as on how the dehydrated alfalfa is handled and on the efficiency of the crew. Estimates varied widely ranging from $5 to $14 per ton. The average cost per ton was $8.28. Rates of labor varied from 70c to $1.00 per hour plus time and one-half over 40 hrs per week. Most of the growers sell alfalfa to the dehydrator plants by cuttings rather than by the year. The prices paid to the grower for alfalfa in 1949 ranged from $6 to $10 per ton (based on dried weight) for the first cutting and increased to $10 to $18 per ton for the last cutting.

Natural gas, used for fuel by practically all of the dehydration plants, ranged in cost from $1.50 to $3.75 per ton of meal produced, depending on the amount of moisture removed from the hay and on the climatic conditions. The average

cost per ton was $2.20. Natural gas prices ranged from 15 to 23c per 1,000 cu ft. The fuel requirements may vary more than 100 per cent from nighttime, when high-moisture forage is being dried and humidity is high, to daytime when hay is drier and humidity is low. Several operators reported that as much as 16,000 cu ft of natural gas were required to produce a ton of meal under severe drying conditions.

Four plants used fuel oil because natural gas was not available. The cost of fuel oil averaged $6.40 per ton of dehydrated meal.

All of the plants are on an industrial rate for electric power. Some plants have a minimum monthly rate or demand charge and others have a sliding scale rate depending on the amount of power used. The electric power ranged in cost from 90c to $3 per ton of meal dehydrated. The average cost per ton was $1.62.

Cost of repairing equipment is a large item. Some companies report repair parts costing as much as $5 per ton of dehydrated meal, while others report as low as $1 per ton. The average cost per ton was $2.57. Repair of field equipment made up the larger part of the repair costs.

Burlap bags, 40 by 60 in, which hold 100 lb meals, are used almost entirely in the industry for sacking meal. Most operators reported the bags cost approximately 20c each. Bags 40 by 44 in, for pellets, will hold 100 lb and cost approximately 15c each. A few companies used some paper bags of 50-lb capacity. The cost of these bags ranged from 11 to 18c each.

Considerably more tonnage of sacked pellets may be stored in an equivalent space than sacked meal. One operator reported storing 1,400 tons of pellets in a space previously occupied by 1,000 tons of meal.

Meal that is not shipped at time of dehydration but placed in storage costs the operator from 50c to $1 per ton to place in storage, 40c to $1 for each month of storage, and 50c to $1 per ton to remove from storage.

The cost of pelleting and bagging meal at time of dehydration averaged $2.60 per ton. If the pelleted meal is run directly into a railroad car for loose shipment, the labor of one man and the price of bags can be saved.

Several operators reported savings up to 3 per cent of the meal when using dust-collecting equipment during dehydration. Better working conditions resulting from dust-free air around the plant and saving in meal should offset the expense of using such equipment.

Blending of meal to produce the desired analysis is usually a separate operation. Several operators reported the cost up to $5.35 per ton. One operator reported no increase in cost to blend meal. This was accomplished by blending meal at time of dehydrating and using a very simple auger feeder which fed the meal to the hammer mill. No extra labor was required as the mill operator attended the equipment.

Product. The percentage preservation of nutrients in the forage during the dehydration process depends to a large extent upon the rate of drying, moisture content of the dried product, and the skill of the operator in adjusting and operating the drier.

The first half of the first-cutting alfalfa and the last crop of the season usually provide the best forage for meal. Protein contents may run as high as 27 per cent, with carotene as high as 200,000 international units per pound. The lowest grade meals are usually obtained from the second and third-cutting alfalfa. A large percentage of the companies reported that more than 90 per cent of the meal produced during a growing season contained 17 per cent or more protein. Of this amount, 5 to 30 per cent contained 20 per cent or more protein.

In dehydration plants where two or three cyclones are used for cooling meal, temperatures of meal usually ranged from 20 to 40 F higher than the surrounding atmosphere. When meal is stored at these high temperatures, the rate of carotene loss is high.

New Equipment. Probably the most needed equipment in the dehydration industry is a lightweight, durable, self-propelled field harvester that is low in cost. Such equipment must operate on hilly land as well as on poorly drained land. It should be easy to maneuver in small fields and between and/or over irrigation ditches. Two makes of commercial self-propelled field harvesters are now being used to a limited extent. Others are in the development stage.

A self-unloading trailer, which is pulled behind field harvesters, is being used by several dehydrator operators. The use of such equipment requires only one field-machine operator with only a few minutes needed to transfer a load from trailer to truck. This eliminates the use of a truck to follow alongside the field harvester.

Equipment to make meal into pellets at time of dehydration is being used to a limited extent. However, a plant having such equipment will seldom be used to pellet the entire production of meal, because the demand for pellets is limited. Pellets are made in three sizes, approximately ¼, ⅜ and ½-in diameter, depending on whether they are intended for chickens, small livestock (sheep, calves), or cattle. Some operators use steam as a binding agent to make pellets, while other operators use water or no treatment at all. One operator reported making small pellets successfully without treating the meal. Pellets are cooled in a bin by forced air circulation. The use of pelleting equipment reduces the dusty conditions at the sacking room.

Equipment that reduces the loss of finely ground meal from collectors is being used at several dehydration plants. This equipment passes all the air from the hammer mill cyclone through a series of small cyclones or bags.

Water or other cooling agent circulated through coils in bins of meal is being used by several companies to cool the meal to or below atmospheric temperatures. Lowering the temperature of meal slows down the carotene losses. Methods for the stabilization of carotene in meal now under study by a number of organizations should provide new techniques for preserving this highly perishable nutrient.

Shredders (sometimes called stem crushers) are being used to a limited extent. The purpose of this equipment is to reduce chopped green forage to smaller particles for quicker and more efficient drying.

SUMMARY

Although the industry is relatively young, it has become highly competitive. Plant managers must be alert for new ideas and equipment to lower the over-all cost of operation and incorporate them in their operations. They must be able to utilize labor efficiently at all times.

Plant shutdowns resulting from insufficient alfalfa, broken-down equipment, or other causes should be avoided. One operator used overhead irrigation on his fields to assure a constant supply of alfalfa. Another operator drained and leveled the land before seeding to prevent drowning or freezing out. Other operators were dehydrating potatoes and sorghum to avoid plant shutdowns.

Many operators expressed the opinion that stabilization of prices for ground and pelleted meal would help the industry.

Dehydrated sacked meal is handled largely by hand throughout the industry. This requires considerable labor and is disagreeable work, particularly when sacking in dusty rooms. Better warehouse practices and equipment should be adopted to reduce handling costs.

Standardized plant layouts should be designed to provide maximum efficiency of operation, to provide the use of standardized parts, and to provide space for expansion of new equipment.

A Correction

THE authors of the paper, entitled "Application of Heat Exchangers to Dairy Barn Ventilation," in AGRICULTURAL ENGINEERING for April, 1950, have called attention to a correction in Table 2 on page 170. The quantity in the line reading, "Moisture removed, etc.," should read 0.965 lb/hr instead of 2.965 lb/hr.

Standards for V-Belt Drives on Farm Equipment

By L. J. Confer

DURING 1949 subcommittees of the Engineering Advisory Commitee of the Farm Equipment Institute and of the V-Belt Technical Committee of the Rubber Manufacturers Association cooperated in drafting recommendations for the standardization of V-belt drives on farm equipment, which are being submitted to the corporate members of the American Society of Agricultural Engineers for consideration and possible adoption as official ASAE standards.

A few years ago the Rubber Manufacturers Association published tentative standards which have had somewhat limited circulation. These standards provided the basis for the new standards, the purposes and expected accomplishments I will discuss. Briefly they define standard cross sections and lengths for the belts, standard groove dimensions for the sheaves, the method of measuring the belts, and methods of determining belt length. The standards will also include recommended forms for drive layouts.

What, more specifically, do we hope to accomplish by these standards for V-belt drives on farm equipment? By simplification of sizes of belts and sheaves and by clarification of terms, we hope to make the most efficient use of materials and human effort. The savings thereby created for the belt manufacturers and for the farm equipment manufacturers can be passed on to the users of farm equipment.

Some of the savings which can be made by observing these standards are as follows:

1 Reduced costs for the belt and sheave makers in manufacturing and warehousing and in many overhead items

2 Reduced overhead items for the farm equipment manufacturer

3 Eliminating errors and delays resulting from misunderstandings of dimensions and terms between the farm equipment manufacturers and the belt makers

4 Reduced inventories, warehouse and obsolescence costs of replacement stocks of the various distribution points between the manufacturers and users of farm equipment.

Tires, for example, are now of standard dimensions in a relatively limited range of sizes. Fan belts on the same equipment are not so standardized. Agricultural belts are still less standardized. The cost, on a pound basis, of fan belts and agricultural belts ranges from four to seven times that for tires. Now there are undoubtedly many reasons for this cost discrepancy which we cannot analyze here, but we may be certain that one reason is the relative standardization within the classes of these products and the resulting relative engineering, production, and distribution costs per size. I cannot think of any one V-belt size which could have ever been made in greater numbers than the current Chevrolet fan belt size which has been the same since the 1936 model and which happens to be the same size as that for the old Model A Ford car. Yet its production has undoubtedly been surpassed many times by that of the 6.00-16 tire.

By far the bulk of automotive belt sizes are for a groove-width range of ½ to 1 in and in a length range of 30 to 70 in. Relatively few automotive belts are outside these size ranges. The size range for agricultural belts is of course much greater. Calculating the number of potential agricultural belt sizes from my company's record of groove widths and angles which have been used on agricultural equipment, and making the naive assumption that, without standardization, the lengths would be confined to 1-in intervals between 50 and 100 in, to 2-in intervals between 100 and 200 in, and to 4-in intervals between 200 and 300 in, a total of about 11,000 potential agricultural belt sizes is obtained. That total would include only the conventional type and standard construction V belts. It does not include double V belts and special construction belts which theoretically could multiply the figure several times.

In the proposed standards for V-belt drives on farm equipment, we recognize as standard the familiar A, B, C, D, and E V-belt cross sections which have been the standard for the industrial or multiple V-belts for many years. Most of the belt manufacturers will, of course, have sufficient mold equipment and the correct stock gages in regular production for these standard cross sections.

The standard sheave grooves shown for these cross sections are those adopted by the association of the multiple groove sheave manufacturers on September 22, 1948, with the concurrence of the Rubber Manufacturers Association.

Four double V-belt cross sections are recognized as standard. These correspond to the A, B, C and D V-belt cross sections, and of course they are designed to operate in the same grooves.

The standard lengths for the V belts and for the double V belts are identical with the standard multiple or industrial V-belt lengths. It should be remembered that production equipment generally exists for these standard lengths. On the other hand, for certain types of construction, my company to build a non-standard 205 in length belt, for example, would need to apply to the nearest shorter available drum, a plastic build-up weighing 200 lb, requiring 8 hr of production time for preparation, and costing about $60 to $75 in material, labor, and overhead. That cost is merely for preparation of the drum to the right size before starting to build the belt.

The length tolerances which are shown in the length tables in the proposed standards include standard manufacturing tolerances and allow for normal shrinkage. Because of the allowance for shrinkage, the negative tolerances are greater than the positive tolerances.

Standard cross sections and lengths are established for adjustable-speed belts. These belts are those such as cylinder drive belts and traction drive belts intended to operate at varying diameters in adjustable width sheaves to obtain various driven shaft speeds. The standard lengths are in 4-in intervals from 60 through 96 in and in 8-in intervals from 96 through 128 in. The concensus of the Farm Equipment Institute Engineering Advisory Committee was that the angle of 26 deg could be adopted as the standard sheave groove angle for these adjustable-speed belts.

Measuring and inspection of V belts has generally been the cause of confusion between belt makers and their customers. Probably more ways have been used to measure belt width and belt length than any one person would conceive. Different belts vary in their cross-section sizes and shape and in their over-all periphery and still are exactly interchangeable on a drive using standard grooves. For satisfactory inspection and measurement, the belt makers in their own routine procedure find it necessary to make both width and length measurements on two measuring sheaves under specified belt tension. This measuring tension is intended to be the operating tension of the belt on the average drive. The length check is made by measuring the center distance between the two sheaves. The width check is made by measuring the distance from the top of the belt to the top of the sheave groove. The standards specify dimensions and tolerances for the measuring sheaves, the measuring tensions, and the riding positions of the tops of the belts in the grooves.

Frequently the sheave dimensions which are given the belt manufacturer do not enable him to select or design the correct belt because he is not certain of the relationship between the outside diameters of the sheave and the diameters at the point where the groove width is actually as specified. Sheave-diameter alone is misleading if there *(Continued on page 254)*

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Illinois, December 1949, as a contribution of the Power and Machinery Division.

The author: L. J. CONFER, engineer, Dayton Rubber Co. (Dayton, Ohio), and chairman, V-Belt Technical Committee, Rubber Manufacturers Assn.

NEWS SECTION

ASAE Annual Meeting Program

WHILE the Washington (D.C.) Section of the American Society of Agricultural Engineers, and particularly its members who constitute the committee on local arrangements, are bending every effort as host to the Society's 43rd annual meeting to be held in Washington, June 19 to 21, to make it a most enjoyable and memorable occasion, the Meetings Committee of the Society has been arranging a most attractive program for the general and technical sessions of the meeting.

The general sessions of the meeting, of which there will be two, are scheduled for the afternoon periods of June 19 and 21 and will feature the annual address of the President of the Society, Frank J. Zink, and addresses by other speakers of national prominence, including Hon. Knox T. Hutchinson, Assistant Secretary of Agriculture, and Russell I. Thackery, executive secretary of the Association of Land-Grant Colleges and Universities.

The evening of the first day, June 19, will be set aside for special meetings and round tables of committees and other groups. The major portion of the meeting will be given over to technical programs arranged by four divisions of the Society — Power and Machinery, Soil and Water, Farm Structures, Rural Electrification — with the inclusion also of a special program by the College Division. The high lights of these division programs are as follows:

Power and Machinery Program

The first session, on Monday forenoon, June 19, will feature the subject of mechanization of Southeast agriculture, opening with a paper on the accomplishments of such mechanization by Geo. B. Nutt, Clemson Agricultural College. This will be followed by a discussion on how mechanization improves soil and water conservation practices by J. R. Carreker, Southern Piedmont Soil Conservation Experiment Station. An illustrated presentation on latest progress on mechanized peanut harvesting will be presented by F. A. Kummer, Alabama Polytechnic Institute. The subject of the possibilities of a low-cost cotton picker for the Southeast will also be discussed.

The program for Tuesday forenoon, June 20, will feature new farm machinery developments. J. W. Martin, University of Idaho, will discuss a new development in potato-harvesting equipment, with which he has been associated. A. W. Clyde, Pennsylvania State College, will follow with a discussion of recent developments of potato-harvesting equipment in the eastern area of the country. The engineering background of a new automatic baler will be presented by Geo. B. Hill, chief engineer, New Holland Machine Co. Some recent results of baled hay curing research will be presented by D. E. Wiant, Michigan State College, and he will be followed by a discussion on some of the equipment aspects of this research by S. D. Russell, J. I. Case Co.

The third session on power and machinery, on Wednesday forenoon, June 21, will feature problems in farm machinery design. Russell R. Raney, chief engineer of advance engineering, International Harvester Co., will open the program with a talk on the training of the farm implement designer. Some of the peculiarities of rubber design as applied to machinery is the subject of a talk by J. D. Berwick, a field engineer of Goodyear Tire and Rubber Co. D. C. Heitshu, chief engineer, John Deere Harvester Works, will present a paper on the place of research in the design of farm machinery.

Soil and Water Program

The opening session of the soil and water program on Monday forenoon, June 19, will deal exclusively with the subject of drainage, and will open with a paper on drainage of irrigated lands by Chas. R. Maierhofer, head of the drainage engineering division, U. S. Bureau of Reclamation. This will be followed by a paper by Lewis A. Jones, chief, division of drainage and water control, Soil Conservation Service, on the importance of maintaining drainage improvements. L. S. Evans, project analyst, Agricultural Research Administration, USDA, will discuss the subject of chemicals for drainage ditch maintenance. The remainder of the period will be devoted to a panel discussion on the maintenance of drains.

The second session, on Tuesday forenoon, June 20, will be devoted to the subject of farm conservation contracting as served by (1) the soil conservation district, (2) the agricultural extension engineer, (3) the consulting engineer. These three aspects of the subject will be discussed, respectively, by Ralph C. Hay, University of Illinois, Marion C. Clark, University of Missouri, and J. R. Benjamin, president, Water Management, Medina, Ohio. Following these three contributions, the remainder of the session will be devoted to a panel discussion on farm power contracting, and the panel will include in addition to the three speakers just named, Dale O. Hull, Iowa State College; M. T. Gowder, University of Tennessee, and a power contractor.

The third session of the soil and water program will be devoted to specialized college training of young engineers who desire to practice in the field of soil and water conservation, and the program is being arranged jointly by the Soil and Water and College Divisions.

Farm Structures Program

The opening session on farm structures subjects, which will be a joint program arranged by the Farm Structures and Rural Electric Divisions, will be devoted exclusively to the subject of farm housing. The first number will deal with the housing program of the Farmers Home Administration under the Act of 1949, with Raub Snyder, assistant administrator of FHA, as the speaker. This will be followed by a joint paper by J. W. McBurney and R. C. Valore, Jr., of the division of research on masonry materials, National Bureau of Standards, on the work of the Bureau applicable to farm construction. J. R. Dodge, agricultural engineer, USDA, will discuss the preparation of plans for the rural housing program. The research program on housing materials and constructions of the Housing and Home Finance Agency will be the subject of a talk by J. H. Orendorff, assistant chief of the housing technology branch of the division of housing research, HHFA. The program of the USDA Extension Service under the Housing Act of 1949 will be discussed by representatives of three state institutions — K. H. Hincliff, University of Illinois; H. E. Wichers, State College of Washington, and C. F. Williams, University of Arkansas.

The program for Tuesday forenoon, June 20, will be devoted to the subject of crop conditioning and storage. Geo. H. Foster, associate agricultural engineer, USDA, will present a paper on methods of conditioning shelled corn at CCC storage sites. The distribution of air in refrigerated apple storages will be discussed by W. Grierson Jackson, graduate assistant in pomology of Cornell University. The results of extensive potato storage research will be presented by A. D. Edgar, USDA agricultural engineer.

The program for Wednesday forenoon, June 21, will open with a joint paper on window insulation and solar orientation of farm structures by W. E. Eakin, in charge of farm structures research, Libbey-Owens-Ford Glass Co., and D. C. Sprague professor of agricultural engineering on leave from Pennsylvania State College. The effects of roofing materials on summer temperature in farm buildings is the subject of a joint paper by Alvin C. Dale, Purdue University, and Henry Giese, Iowa State College. Allan E. Brickman, development engineer, American Steel and Wire Co., will discuss the characteristics and applications of welded wire fabric in the field of agriculture.

Rural Electric Program

In addition to the program on farm housing being arranged jointly by the Rural Electric and Farm Structures Divisions on Monday, June 19, the Rural Electric Division has arranged a program for Tuesday forenoon, June 20, which will open with a paper on the economic aspects of rural electrification by Joe F. Davis, Bureau of Agriculture Economics, USDA. The subject of electricity in the farm home will be presented by an outstanding home economist.

A third program dealing with rural electrification will be sponsored jointly by the Rural Electric and College Divisions dealing with specialized training of young agricultural engineers who desire to specialize in the field of rural electrification.

Aside from the joint programs with the Farm Structures and Rural Electric Divisions, the College Division is arranging for a special program which will be presented either on Monday evening, June 19, or on Thursday, June 22.

Further information regarding the program, arrangements, accommodations, etc., in connection with the Society's annual meeting may be obtained by writing the society headquarters at Saint Joseph, Michigan.

A.S.A.E. Meetings Calendar

June 19-21 — ANNUAL MEETING, Hotel Statler, Washington, D. C.

August 28-30—NORTH ATLANTIC SECTION, University of New Hampshire, Durham

October 19 and 20 — PACIFIC NORTHWEST SECTION, Yakima, Wash.

December 18-20 — WINTER MEETING, The Stevens, Chicago, Ill.

Exhibits at ASAE Meeting in Washington

NEARLY 300 lineal feet of floor and wall space will be made available in three main foyers in the Hotel Statler in Washington during the ASAE annual meeting, June 19 to 21. Arrangements for displaying educational exhibits should be made with members of the ASAE Committee on Extension, in accord with the type of exhibit it is desired to display, as follows:

1 Better bulletins and class room instruction manuals — M. R. Dunk, Sandstone Building, Mount Morris, Illinois

2 Demonstration models — K. H. Hinchcliff, agricultural engineering dept., University of Illinois, Urbana

3 Press and radio releases — Dale O. Hull, agricultural engineering dept., Iowa State College, Ames

4 New agricultural engineering textbooks — T. E. Long, Portland Cement Assn., 33 W. Grand Ave., Chicago

5 Slides and film strips — Glen O. Schwab, agricultural engineering dept., Iowa State College, Ames

6 Safety exhibits — A. E. Heston, National Association of Mutual Insurance Companies, 2105 N. Meridian St., Indianapolis 7, Ind.

7 Master movie — I. D. Mayer, agricultural engineering dept., Purdue University, Lafayette, Ind.

Prospective exhibitors should furnish the following information concerning the requirements of their exhibits: (1) lineal feet of floor and wall space needed, (2) square feet of table space needed (tables are 3 x 5 feet), (3) number of easels needed for vertical or wall exhibits, (4) number of electric outlets needed for electrical operated displays.

Each exhibitor is responsible for his exhibit, including its transportation and assembly. Facilities will be provided for setting up the exhibits on Sunday, June 18. The committee on local arrangements for the ASAE meeting in Washington desires to supply the best available space and equipment for the educational exhibits. To do this it will be necessary for prospective exhibiters to make their requests to those in charge of the various types of exhibits as promptly as possible.

Open House for ASAE Members Enroute to Washington

THE Virginia Section of ASAE and the agricultural engineering department of Virginia Polytechnic Institute, Blacksburg, will keep open house, Saturday, June 17, to all ASAE members and others enroute to Washington, D. C., to attend the Society's annual meeting, June 19 to 21,

Persons traveling highway routes that take them near Blacksburg will find that city a convenient stopover point, as it is a comfortable day's drive from there to Washington. The agricultural engineering building on the VPI campus will be open all day, June 17, and six members of the department — V. H. Baker, U. F. Earp, M. H. Kirkpatrick, G. D. Kite, McNeil Marshall, J. A. Waller, Jr. — will welcome visitors and will also be glad to be of any possible service, such as procuring overnight accommodations or travel information.

Special Washington Tours for A-E Members

SPECIAL provision is being made for the benefit of the ASAE members and others attending the Society's annual meeting at Washington, D. C., June 19 to 21, to visit three points of technical interest in and around Washington, in addition to special trips of historical interest in the area which are being arranged. This special trip will include a visit to the exhibit room of the Naval Research Laboratories at Anacostia, to the University of Maryland Wind Tunnel, and to the USDA Research Center at Beltsville, Md.

The NRL exhibit room is designed to give visitors a fair sampling of the Navy's research activities. It is by no means comprehensive, but the random sampling of projects reveals some of the directions of the Laboratory's research efforts.

Loyalty clearance, however, must be obtained in advance by anyone who desires to visit the NRL exhibit room, and those who wish to make this special trip should have the following information in hands of A. V. Krewatch, agricultural engineering dept., University of Maryland, College Park, not later than May 25th; (1) name and address of each individual, (2) business connection, and (3) name of country of which he is a citizen. The Navy will check on persons who register for this trip prior to June 18.

Engineers to Participate in Tobacco Workers' Conference

AN ENGINEERING section of the Tobacco Workers Conference will be organized at Gainesville, Fla., during June 6 to 9.

The Tobacco Workers Conference was first started a number of years ago by agronomists working in the flue-cured tobacco area. They later invited the pathologists to meet with them and form a pathology section, and the entomologists to form an entomology section. The engineers have been invited to form an engineering section at the June conference.

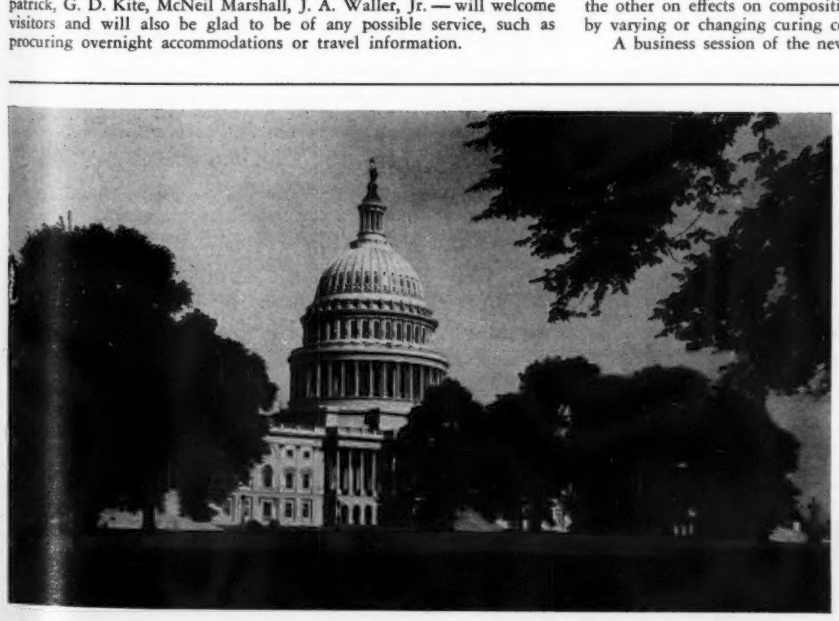
The conference is attended mainly by research and extension men working with tobacco. Although it is sponsored by workers in the flue-cured area, engineers and others outside the area are invited to attend and to take an active part in the meeting.

An interesting program for the engineers at the June meeting is being formulated under the direction of program leaders (all ASAE members). A half-day on curing, grading and marketing is scheduled under program leader, Dr. O. A. Brown, USDA. J. L. Shepherd of Georgia will lead a half-day program on the mechanization of production and harvesting. A joint program of engineers and agronomists on irrigation, topping, spacing, and suckering is under the leadership of W. P. Law, Jr., of South Carolina.

J. M. Myers of Florida is in charge of field demonstrations and trips. Present plans are to have a full day devoted to this. Manufacturers will be on hand to demonstrate some of their equipment.

A joint session with the agronomists on physiology and biochemistry contains two interesting talks, one on comparative analysis of tobaccos cured in the presence of and absence of combustion gases, and the other on effects on composition of flue-cured tobacco leaf produced by varying or changing curing conditions.

A business session of the new engineering section—not open to the



High on a hill in the city of Washington, D. C., the U. S. Capitol dominates the skyline of the nation's capital city day and night, a symbol of government and of this country's democratic system. Always a center of interest, it will be one of the special attractions for members of ASAE during the week of June 18 when the Society holds its 43rd annual meeting in Washington for the first time since 1928. Those attending the meeting will find Congress still in session, and a visit to the legislative halls in the Capitol will be a "must" on their itinerary, especially for those who combine a vacation trip with the annual meeting and take their families. In any case, however, this year's ASAE annual meeting will provide good reason for visiting many points of historical interest in and around Washington. Going to attend? Sure you are. It's time now to make your plans

public—will be held one evening. Among other important tasks will be the election of a chairman and secretary for the 1951 conference. G. W. Giles of North Carolina will act as chairman and V. H. Baker of Virginia will be the secretary for this first meeting. It is planned to publish the proceedings of each conference.

The host for the engineering section is agricultural engineering staff of the University of Florida. The location for each yearly conference rotates among the respective states and the 1951 location is yet to be decided.

All interested persons are cordially invited to attend the Gainesville conference, June 6 through 9. A copy of the program may be secured from V. H. Baker, agricultural engineering dept., Virginia Polytechnic Institute, Blacksburg. The agricultural engineering dept., University of Florida, Gainesville, will supply information on room accommodations.

Mid-Central Section Elects John Wooley

JOHN C. WOOLEY, professor emeritus of agricultural engineering, University of Missouri, was elected chairman of the Mid-Central Section of the American Society of Agricultural Engineers at the business session of the Section's yearly meeting held April 7 and 8 at Lincoln, Neb. The three new vice-chairmen of the Section elected at the meeting are, respectively, C. E. Fairbanks, assistant professor of agricultural engineering, Kansas State College; H. E. Everett, editor and vice-president, "Implement and Tractor", and F. D. Yung, research engineer in rural electrification, University of Nebraska. M. M. Jones, head, agricultural engineering department, University of Missouri, was elected the new secretary-treasurer of the Section.

The attendance record of the meeting showed that the total attendance was 140 persons including ASAE members, students, and visitors.

At the business session, it was voted to extend the Section's invitation to the parent society to hold its 1952 annual meeting in Kansas City.

The newly elected board of directors of the Section voted to hold the 1951 Section meeting at Columbia, Mo.

Tennessee Section Meets in June

THE spring meeting of the Tennessee Section of the American Society of Agricultural Engineers will be held during the week end of June 2, 3, and 4 near Gatlinburg, Tenn., at the Smoky Mountain Lodge, operated by W. C. Gillham, a member of the Section. The attractions offered by this meeting include boating, fishing, hiking, swimming, sightseeing in the Smoky Mountains, etc. Any ASAE member who may be in that vicinity at the time of the meeting is cordially invited to attend. Reservations for the meeting may be made direct with Edwin J. Mathews, Section secretary, agricultural engineering department, University of Tennessee, Knoxville.

Dr. J. B. Davidson Honored by Historians

"THE PALIMPSEST," monthly bulletin of the State Historical Society of Iowa, devoted its March 1950 issue to several short papers by Dr. J. B. Davidson, on "Primitive Farm Implements," "Advent of Machine Production," "The History of Farm Machines," and "Influence of Farm Machinery."

The publication also includes a brief biographical note on Dr. Davidson, written by the editor, Wm. J. Petersen. This issue may be obtained from the State Historical Society, Iowa City, Iowa, at 15 cents per copy.

EEI Farm Section Program

DEAN of Agriculture L. L. Rummell, Ohio State University, key noted the farm section program of the 16th annual sales conference of the Edison Electric Institute held in Chicago, April 4, by emphasizing five points on the opportunity in the farm market for the electric industry.

In addressing the farm section luncheon, Dean Rummell reviewed these points substantially as follows: (1) The farmer of today is alert to the need for increased efficiency in his farming operations, as well as eager to provide those helps which contribute to the comfort and security of farm living. Housing surveys reveal that many rural people plan to modernize their homes and farms, which indicates a tremendous demand for water systems, bathrooms, home appliances, and farm equipment in which electricity is the vital factor. (2) The farm people today have the cash with which to accomplish their goals of farm and home improvement. Even though farm income is declining, the efficient farmer is apt to remain in a satisfactory buying position. (3) The age of the farm population has reversed in the last few decades. A larger percentage of workers are now over sixty years old than are under thirty years. This represents an age group which needs the benefits offered by electrical helps and which has the ability to buy them as the desire for them occurs. Electricity is also needed to keep farm youth by making the farm a more pleasant and productive place in which to live. (4) Lights are not enough. More than 50 per cent of farms could profitably utilize more electrical equipment. This important job can be accomplished with the help of extension specialists. (5) There are still a large number of farms without electrical service. There are many unconnected farms next to power lines.

In conclusion he emphasized that education is a prerequisite to sales. Misguided economy and stubbornness still persists, but the majority of rural people are awake to the fact that electricity is no longer a luxury but a necessity of modern farm living.

The challenge in the farm market was further explored in the morning session by J. C. Cahill, chairman of the Section; Ed Smith, a member of the Farm Utilization Committee, outlined the farm load-building program for 1950; C. D. Leiter, sales manager, F. E. Myers & Bro. Co., pointed out the great lack and need for electric water systems on the nation's farms; A. B. Collins, president, Reddy Kilowatt Service, emphasized the necessity for more and better advertising.

Youth, their activities and importance as future customers of the electric industry, was accented in the afternoon program by H. J. Gallagher, chairman, Rural Youth Activities; A. G. Kettunen, state 4-H Club leader, Michigan State College; R. T. Jones, chairman, Agricultural Development Committee; and A. G. Mayer, farm development manager, Washington Water Power Co.

Necrology

JOHN MACGREGOR SMITH, professor of agricultural engineering, University of Alberta, Edmonton, passed away at his home April 18, at the age of 62. He had been in failing health for several months.

A native of Scotland, he had studied at Daniel Stewart's College, Heriot-Watt College of Engineering, University of Edinburgh, and the East of Scotland College of Agriculture before moving to Canada. Continuing his studies at the University of Manitoba, he received his bachelor's degree in agriculture in 1913. He went to the University of Saskatchewan as assistant professor of agricultural engineering, and was promoted to associate professor in 1918. From this position he was appointed professor of agricultural engineering at the University of Alberta effective January 1, 1921, and continued in that position for 29 years, until his passing. In addition he had served on occasion as acting dean of agriculture, and on various faculty committees.

A member of ASAE since 1916, he was elected a Fellow in the Society in 1938. He was also a charter member of the Agricultural Institute of Canada, a member of the National Agricultural Engineering Committee, western section, a Rotarian, and a charter member of the Mayfair Golf and Country Club. He is survived by his wife and also his mother.

Personals of A.S.A.E. Members

Roy B. Davis, Jr., has resigned as associate agricultural engineer (BPISAE), U. S. Department of Agriculture, to engage in tobacco and livestock farming on his home farm near Paces, Va. Stationed at Blacksburg, Va., for several years Mr. Davis's contributions to hay drying research have been outstanding.

Ralph C. Hay, associate professor of soil conservation, University of Illinois, and past-chairman of the ASAE Soil and Water Division, is serving as a member of the Engineers Joint Council Committee on Flood Control and Water Flow Retardation, which committee is one of eight set up to make recommendations on the national water policy.

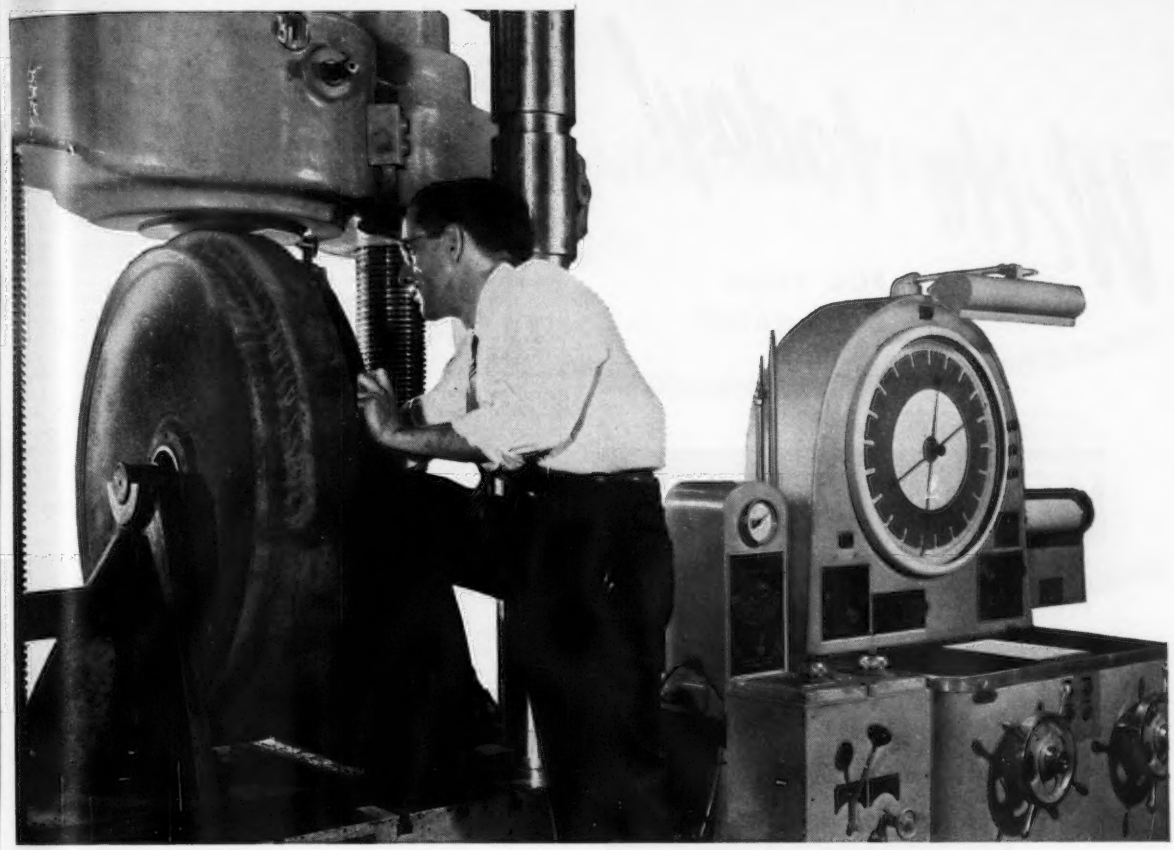
Joe C. Johnson recently resigned as instructor at the Campbell High School, Campbell, Missouri, and is now employed as an engineer trainee on the Tucumcari Irrigation Project at Tucumcari, New Mexico.

A. G. Levorson reports that his new address is E C A Mission to Turkey, care of American Embassy, Ankara, Turkey. He recently joined the Mission as specialist in farm machinery. Before undertaking this assignment he was research agricultural engineer with the Minnesota Valley Canning Company of Le Sueur, Minn.

Joseph A. McCurdy has resigned as farm representative of the Pennsylvania Power and Light Co., to accept appointment as extension agricultural engineer, Pennsylvania State College, State College. His activities will be devoted mainly to work with the county agricultural agents of the state.

Clark Prudhon for several years employed as research and development engineer for James Mfg. Co., resigned May 1st to devote full time to a new organization, Pruden Products Co., Fort Atkinson, Wis., specialists in farm buildings and equipment. The company will be a design and sales organization dealing with a few selected items.

W. J. Welker recently resigned as service manager of John Bean (Western) Division, Food Machinery and Chemical Corp., to take a position in the sales department of The Massey-Harris Co., at Racine, Wis.



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NEW BOOKS

Rural Electrification Engineering, by Unus F. Earp. Cloth, ix + 313 pages, 6x9 inches. Illustrated and indexed. McGraw-Hill Book Co. (New York, Toronto, London) $3.50.

This is a first edition extending the technical field covered in the publisher's agricultural engineering series on which Quincy C. Ayres is consulting editor. It is believed to be the first text developed primarily for courses in rural electrification in the professional agricultural engineering curriculum. The treatment is such that considerable engineering mathematics and physics would be prerequisite to effective use of the text. A chapter on electrical fundamentals is included for use by students who have not covered this ground in electrical engineering courses or advanced engineering physics, and for a refresher where desirable. Its advantage over standard texts in the electrical engineering field is its repeated focussing of attention on conditions, problems, and applications encountered in rural electrification, in chapters on rural distribution systems, types of construction, materials of construction, fundamentals of rural distribution line design, layout and over-all design of rural distribution lines, mechanical design for rural lines, electric motors, switches and controls, heat, radiation, electronics, electrical measurements, financial considerations, and organization and administration. In brief, the text treats rural electrification engineering as a specialized application field of electrical engineering with due recognition to the jobs which electricity can do for agriculture, and the unique distribution and service conditions encountered.

A Report on Agriculture and Agricultural Engineering in China, by the Committee on Agricultural Engineering in China, (E. L. Hansen, H. F. McColly, A. A. Stone, and J. B. Davidson.) Cloth, viii+ 259 pages, 8½x11 inches. Illustrated. Publisher and price not stated. (For further information, inquiries should be addressed to the sponsor of the project, International Harvester Company, Chicago, Ill.)

This is a comprehensive report on an educational program for the introduction of improved production techniques into the agriculture of China. The project was proposed and requested by the Ministry of Agriculture and Forestry of China, sponsored by the International Harvester Co. and a number of cooperating manufacturers, and executed largely under the active supervision of the Committee on Agricultural Engineering in China, within the period from 1945 through 1949.

Phases of the program covered in the report include the origin and objectives of the Committee on Agricultural Engineering, institutions with which the Committee was associated; Chinese agriculture and its relation to transportation, manufacturing and mineral resources, research and demonstration program of the Committee, results of research and demonstration, the educational program; International Harvester fellowships, the selection of farm machinery, soil and water conservation, rural housing and sanitation, special topics, and appraisal of results and suggestions for the future. The latter lists 20 specific accomplishments, even though the program of the Committee could not be carried on over the full period planned due to political conditions. Nine recommendations for conserving and extending the values of the work accomplished are listed.

National Tractor and Farm Implement Blue Book (1950 Edition). Paper, ring binding, 190 pages 4½x6½ inches. Indexed. National Market Reports, Inc. (Chicago 5, Ill.) $3.50.

An up-to-date appraisal guide indicating average tradein and resale values for various common makes of some twenty major items of farm equipment. Brief specifications are given to facilitate comparison of models and sizes of different makes of each type of machine.

New Bulletins

A Study of Haymaking Methods, by H. C. Green and F. S. Mitchell, National Institute of Agricultural Engineering (Wrest Park, Silsoe, Bedfordshire, England.) This is a brief mimeographed summary of an investigation, during the summer of 1947, of various methods of haymaking practiced in Scotland, Yorkshire, and Wiltshire. It covers one phase of a "Farm Mechanization Enquiry" conducted by the Institute.

Progress Report, 1949, Washington Farm Electrification Committee, by W. E. Matson and J. Roberts. Presents information on bean vine drying, some tested uses of electricity on the farm, mechanics of handling pear waste, and brooding studies. Not intended for general publication.

Rural Sewage Disposal, by H. W. Kitching and T. R. C. Rokeby. Ontario Department of Agriculture (Toronto) Bulletin 471 (October, 1949). Practical information for the guidance of owners and builders in rapidly developing rural areas.

Earth Dams for Farm Reservoirs, by Earl G. Welch. Circular 470, Agricultural Extension Division, University of Kentucky (Lexington) June 1949. A guide to farmers and custom builders, showing how farm reservoirs should be built under conditions commonly found in Kentucky.

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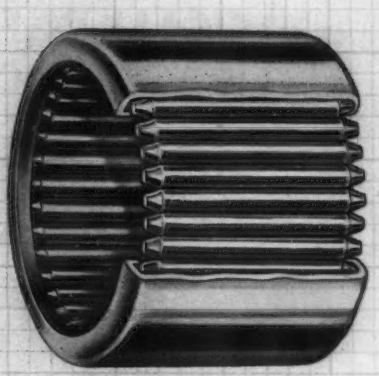

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NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

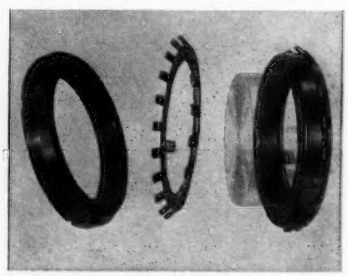
John Deere Small Grain Elevator. John Deere, Moline, Ill., announces the addition of a new many-purpose small grain elevator to its line of farm implements. The versatile elevator loads bins or box cars, takes grain from bins, and picks up grain from piles in the field. It eliminates the hard work of hand scooping, reduces man-hours, and speeds up harvests to cut grain-handling costs. The new elevator may be equipped with a big-capacity hopper for loading bins or box cars or with an extension auger and hopper for emptying bins and picking up

The new John Deere small grain elevator

grain piles. Either attachment comes as regular equipment with the other as an extra. It is available in 22 and 30-ft sizes. The elevator is built for many years of service. Elevator sections are made of heavy tubular steel. Big-capacity, long-wearing rubber flights will not damage grain. A well-braced, tubular-steel truck, carried on roller-bearing, rubber-tired or steel wheels, give plenty of support and maneuverability. The elevator is driven by an enclosed, trouble-free roller chain.

• • •

Link-Belt Locknuts and Lockwashers. The Link-Belt Co., Chicago, Ill., announces the manufacture of a line of bearing-positioning locknuts and lockwashers, specially designed for effectively locking the various makes of ball and roller bearings in correct position on shafts of 5/16 to 7 11/16 in diameter. Advantages claimed are: precision manu-



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facture to ABEC and SAE standards; attractive appearance; easy to install and remove; rust resistant; vibration proof; smooth and burr-free. Detailed dimensions are contained in a 4-page illustrated folder (No. 2348) which will be sent to any interested reader upon request to Link-Belt.

• • •

Massey-Harris Buyers' Guide. The Massey-Harris Co., Dept. B, Racine, Wis., has just announced that their 1950 "Buyers' Guide" is now ready for free distribution. Printed in 4-colors, the 36-page book includes photos and descriptions of nearly all of the company's full line of farm machines and implements. The first part of the catalog deals with tractors and tractor-mounted tools such as cultivators, listers, bedders, and planters. Pull-type implements follow including plows, drills, and disks. The combine section, starts with pull-type combines and progresses to the self-propelled models. Following this is a section on hay tools, including the M-H forage clippers, and finally a miscellaneous group of tools including cream separators and the new M-H Roadmaster wagons.

(Continued on page 246)

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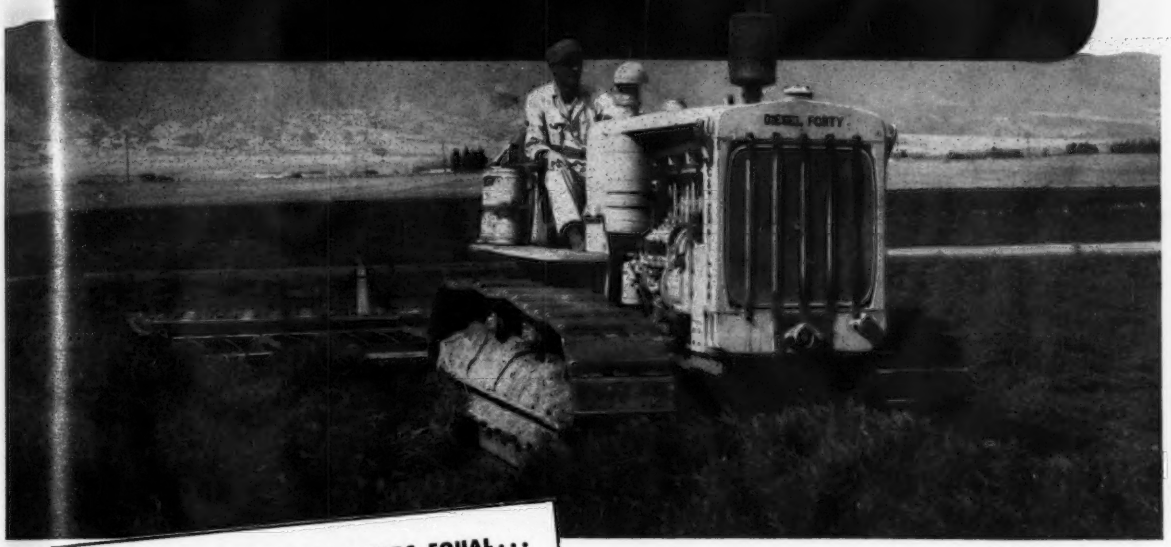

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. . . at least 1,500,000 miles on an automobile at 30 m.p.h.
. . . over 64 years of tractor performance on the average farm

● Veteran "Caterpillar" Diesel Forty Tractor No. 3G40 continues to do her share of heavy work, along with 7 younger Diesels of this make—after 63,988 hours of drawbar work on heavy black land, for Major Distributing Co., Salinas, California.

Total upkeep expenses *(repairs and labor)* on No. 3G40, working this tremendous hour total, approximates $6,000 . . . about 10¢ an hour, average. And for 14 busy years, this tractor has done heavy jobs as they came . . . from plowing, chiseling, ditching to heavy-duty cover crop disking.

"Heavy construction where needed, and proper exclusion of dust and dirt from oil and fuel are responsible for its long life," states S. V. Christierson, president, Major Distributing Co., famous for lettuce.

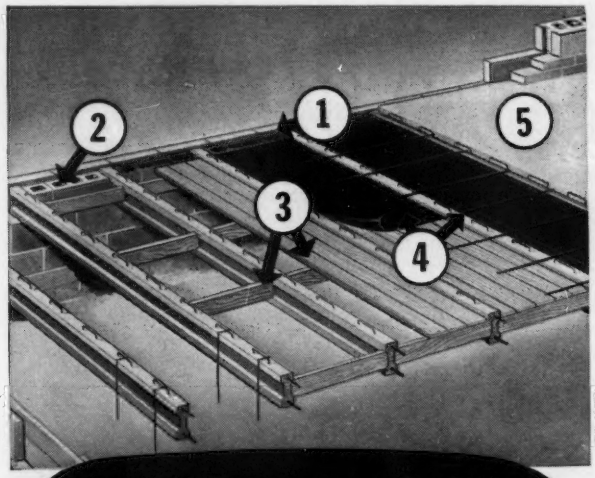
It was 14 years, a world war, and tens of thousands of yellow Diesel machines ago that "Caterpillar" built No. 3G40. Since then, the company has made great progress in heat-treating steels . . . in getting ever closer to seal and filter perfection . . . in developing stronger, longer-lasting gears.

The bonus years of low-cost performance that Caterpillar builds into Diesel tractors should appeal strongly to forward-looking farmers who want low costs!

CATERPILLAR TRACTOR CO. • PEORIA, ILLINOIS

CATERPILLAR

DIESEL ENGINES • TRACTORS • MOTOR GRADERS • EARTHMOVING EQUIPMENT



Here's how you build a PRECAST JOIST CONCRETE FLOOR

Within recent years, precast joist concrete floors have found wide use in farm homes due to the simplicity of form work and construction procedures. In most areas, precast concrete joists are available in three sizes—8-in., 10-in., and 12-in.—for maximum spans of 16, 20 and 24 feet.

Precast joist concrete floors are easy to build. However, for maximum customer satisfaction, every job should be designed by an agricultural engineer.

The above illustration shows the five steps in building precast joist concrete floors:

1. Build exterior walls to a floor height and set precast concrete joists according to setting plan.
2. Space ends of joists by setting bridging between joists at supports.
3. Place spreaders between joists and lay 1″ sheathing on spreaders. Box openings for utilities.
4. Lay paper (if used), place two-way reinforcement for slab and place conduits for wiring, plumbing and heating facilities.
5. Place and finish concrete floor, using properly proportioned and mixed concrete. Moist cure for 5 to 7 days before stripping forms.

Precast joist concrete floors are firesafe and in homes make an ideal base for any floor finish desired—wood, tile, linoleum or carpeting. Write for free booklet, "*How To Design and Build Precast Joist Concrete Floors.*" Available only in U.S. and Canada.

PORTLAND CEMENT ASSOCIATION

Dept. 5-1, 33 W. Grand Ave., Chicago 10, Ill.

A national organization to improve and extend the uses of portland cement and concrete . . . through scientific research and engineering field work

News from Advertisers

(Continued from page 244)

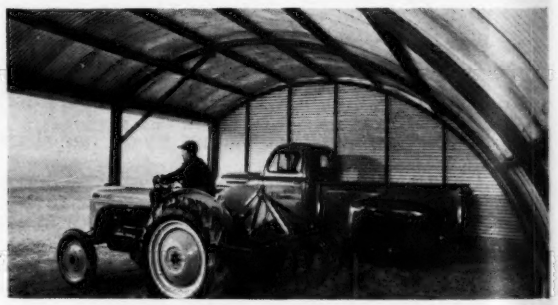
Dearborn Lime and Fertilizer Spreader. Dearborn Motors Corp., Detroit, Mich., announces the addition of a new lime and fertilizer spreader to the Dearborn line of farm equipment. The hopper has a capacity of from 1,000 to 1,250 lb, depending on the condition of the fertilizer. The bottom, which is form-fitted to the agitator for uniform, clog-free dispersal of fertilizer, is perforated by 16 flow holes. The agitator is the split-disk type designed to pulverize the fertilizer thoroughly and to

Dearborn lime and fertilizer spreader

force the mixture through the dispersal holes. A lever to regulate the flow of fertilizer is accessible from the tractor seat. The flow can be regulated at any amount from 100 to 5,000 lb per acre, depending on the type of material being spread. The spreader can be quickly and easily attached to the drawbar of any tractor and a tow plate made of reinforced steel is located at the rear of the hopper for pulling harrows or other equipment.

• • •

Low-Cost Utility Quonset. A new, low-cost utility building is being added to the Quonset line, it is announced by the Great Lakes Steel Corp., Stran-Steel Div., Detroit, Mich. The new economy building is the Quonset 24 Special with an inside width of 24 ft, and a length in any multiple of 12-ft units. Styled with one straight side it offers the building buyer a quality, firesafe structure at the cost of ordinary-type construction for general utility purposes. The framework design features



Utility Quonset building

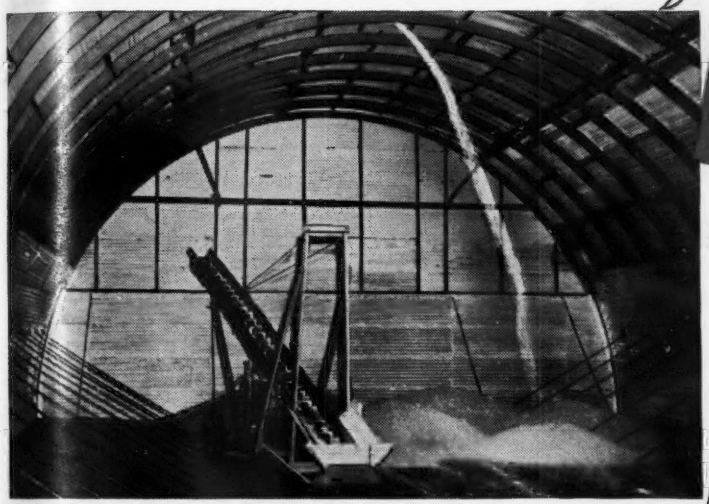
high-tensile alloy steel and provides savings by minimizing material, parts and labor required without sacrifice in size, strength or durability. The N-A-X Hi-Tensile alloy steel used for principal support members in the Quonset 24 has a marked resistance to corrosion as compared with carbon steel, ordinarily used for framing manufactured metal buildings of this size.

• • •

Booklets on Douglas Fir Plywood. The Douglas Fir Plywood Assn., Tacoma Bld., Tacoma 2, Wash., has recently issued three new informative booklets about its product. The first booklet is the 1950 basic catalog for Douglas fir plywood which describes the interior and exterior types of plywood and the new grade designations. The catalog also gives detailed information on the physical properties and gives recommended uses and construction highlights for each of the various grades of plywood. The second booklet is a 31-page reprint from the January issue of "American Builder" which points out the many uses made of plywood in light construction today for sheltering, subflooring, roof decking, exterior paneling, interior finishing, concrete forms, and farm buildings. The booklet also illustrates the adaptability of plywood to unusual desgns and its importance in the prefabricated house. "Better Farm Buildings with Exterior Plyood" is the title of the third booklet which covers the use of construction of plywood farm buildings and equipment. It contains basic "how-to-do-it" information and suggestions on building more profitable farm buildings, and gives specific data on all types of farm structures, including farm *(Continued on page 248)*

DOUBLE USE OF QUONSETS ADDS TO FARM INCOME

Versatile, all-steel buildings safeguard crops—serve as farm shelters the year around



YOU NAIL TO STRAN-STEEL FRAMING

Stran-Steel and Quonset Reg. U.S. Pat. Off.

Quonsets for crop storage! Here is one way to add to farm income. Use Quonsets! Hold your crops for highest prices! Strong, sturdy, durable, all-steel Quonsets provide maximum protection for stored crops at a low cost per bushel . . . provide the utmost in usable space. Quonsets can easily be partitioned to store more than one crop at once.

STRAN-STEEL QUONSETS

- adaptable
- permanent
- all-year usefulness
- quick erection

Your best buy in farm buildings

Quonsets for equipment storage! You have no worries about equipment when it is sheltered from wind and weather in a Quonset! The versatile fire-resistant Quonset is the best answer to the general equipment storage problem during off seasons . . . eliminates the need for an extra storage building.

see your dealer today!

Quonset 32 Quonset 24 Quonset 40

GREAT LAKES STEEL CORPORATION

Stran-Steel Division • Ecorse, Detroit 29, Michigan • UNIT OF NATIONAL STEEL CORPORATION

Soil Conservation is your concern and ours

Your job and the jobs of everyone who sells to farmers depend on a prosperous agriculture. That's why American Steel and Wire Company has taken an active part in promoting soil conservation. You, too, can help by urging farmers to put soil conservation plans into immediate operation wherever they are feasible.

HOW FENCE AND WIRE PRODUCTS FIT INTO THE PROGRAM

U-S-S AMERICAN FENCE

offers the best means available for keeping livestock under control. Livestock should be excluded from wood lots, ponds and erosion-scarred areas that are being revegetated. In pastured areas, fence is an important TOOL OF FARM PRODUCTION that enables livestock to harvest their own feed.

AMERICAN WIRE FABRIC

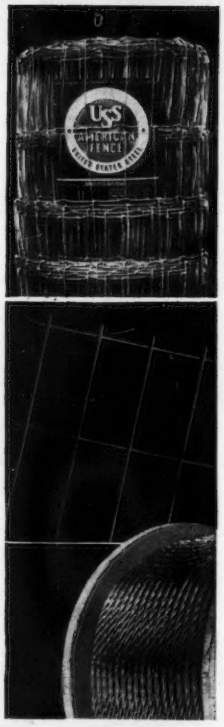
is an excellent reinforcement for concrete dams, flumes, spillways and irrigation ditches.

TIGER BRAND WIRE ROPE

is used on earth-moving equipment, for hoists, tow ropes and other applications around the farm.

AMERICAN ELECTRICAL WIRE & CABLE

are used for REA lines and offer a type of cable for every farm use. Special rubber-covered cables are designed for underground use to distant wells and pumps.



Send for our booklets, "It's Your Top Soil," "The Wire Rope Handbook" and "Wire Fabric Manual."

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS UNITED STATES STEEL

News from Advertisers

(Continued from page 246)

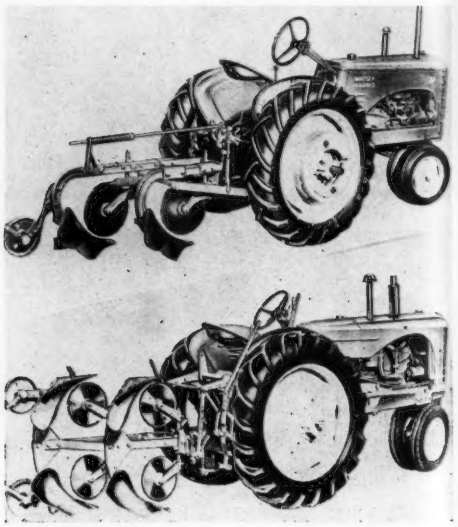
homes, service buildings, remodeling recommended building procedures, and how to apply, fasten and finish plywood. Fully illustrated with over 100 photographs, charts, tables, and construction details. Single copies of these booklets may be obtained without charge from the Douglas Fir Plywood Assn.

• • •

Baldwin-Rex Chain Bulletin. The Baldwin-Duckworth Division, Chain Belt Co., Milwaukee, Wis., has just published a bulletin No. 50-6, illustrating and describing the Baldwin-Rex "BA" Riveted Roller Chain Assembly, copies of which will be sent on request to the Company. Fully explained is the "BA" assembly, which is a standard riveted roller chain with a special single pin connector link. It is assembled at the two-foot mark and at the end of each basic five-foot-length chain. The connector pin can be driven out very easily when assembling or disassembling the chain. In addition to regular five-foot basic length sections, the "BA" assembly is supplied in standard short sections of two, six and ten-pitch units. Tables and examples are provided showing suggested combinations of these units for various length drives. Construction diagrams, illustrations, list prices, specifications and dimensions are also included in the new bulletin.

• • •

Two New Massey-Harris Plows. The Massey Harris Co., Racine, Wis., have recently added two new plows to their line of farm implements — the No. 32, a 2-bottom mounted plow, and the No. 33, a two-bottom, two-way "roll-over" mounted plow. The No. 32 is easily mounted with simple pins and latches without removing the drawbar. Plow is raised and lowered by the "depth-o-matic" hydraulic system. Floating design of the plow makes it enter the ground nose first, and leave the ground nose first, avoiding the stresses and strains of parallel lifting, and providing faster penetration, according to its designers.



The new Massey-Harris Nos. 32 and 33 plows

Downward pressure is exerted through to assure steady operation under difficult conditions. The No. 33 is ideally suited for all types of contour work and other uses where dead furrows are undesirable. Considerable time is saved because at row ends the operator simply turns, rolls the bottoms over easily, and continues plowing in the opposite direction. Minimum hook-up time is required with 4 attaching points. An added safety feature is the double latch which securely locks the bottoms in either position. This plow is also adapted to "depth-o-matic" two-way hydraulic system for lifting and lowering. Both plows are available with 12, 14, or 16-in bottoms.

New Bulletins

North Dakota's Agricultural Progress Through Research (Annual Report of the North Dakota Agricultural Experiment Station) Station Bulletin 356 (January 1950). Brief summaries of research results are grouped according to farm interests in soils, crops, livestock, etc., rather than by the subject matter and administrative departments in which they originated. Contributors and their departments are indicated. Brief administrative information is included.

How a Little Steel adds "Acres" to a Farm!

Dearborn FARM EQUIPMENT

Many farmers have a "roof" *under* the top six or eight inches of their soil. They call it "hard pan."

Subsoilers were invented to rip this roof, let rain drain through to the nutrient and moisture storehouse below. Plant roots, no longer stymied, also are able to go down and tap this supply. Naturally, crop yields go up and so does the farmer's income.

There's nothing wrong with the idea. Trouble is, it *hasn't happened* on all too many farms. Why? Because it *has been* expensive!

The New Dearborn Subsoiler and the Ford Tractor, pictured here, now bring subsoiling and its many benefits within the practical reach of farmers everywhere. Instead of weighing around 500 pounds, the Dearborn Subsoiler weighs only 100 pounds! Its wheels are not as high as a man's thigh, nor its axle as thick as a man's wrist—for it has *no* wheels and *no* axle!

What's more, it does not require a tractor of the size contractors own to pull it; the Ford Tractor has more than adequate power for the job. This means then, that the farmer need not contract for his subsoiling; he can do it himself with the Dearborn Subsoiler and his Ford Tractor, the same tractor he uses for his regular farm work. And he can go down as far as 18 inches to rip hard pan—to destroy his income-stealing roof.

Space does not permit a discussion here of the many reasons why the Ford Tractor and this rugged, inexpensive Dearborn Subsoiler can turn in this miraculous performance. Yet anyone concerned about the future of American agriculture will want the full story.

To get complete information we invite you to write to us direct or to ask your nearby Ford Tractor dealer for a demonstration.

Ford TRACTOR

DEARBORN MOTORS CORPORATION • DETROIT 3, MICHIGAN

Ford Farming

MEANS LESS WORK . . .
MORE INCOME PER ACRE

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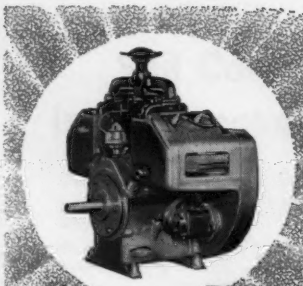


Preferred for
PEAK PERFORMANCE
15 to 30 H. P
V-Type Four-Cylinder
WISCONSIN
Model VE-4, V-type 4-cylinder standard engine 21.5 hp. at 2400 rpm.
HEAVY-DUTY *Air-Cooled* **ENGINES**

On power jobs that call for rugged serviceability and sustained operation in the 15 to 30 hp. range, Wisconsin 4-cylinder engines rate *first preference* on the basis of such features as:

Trouble-free Air-Cooling at all temperatures from sub-zero to tropical highs; tapered roller bearings at BOTH ends of the extended crankshaft to take up all thrust and radial loads (also inherently self-cleaning); rotary type, high tension OUTSIDE Magneto equipped with Impulse Coupling for quick starting in any weather and sure firing on the job; individual oil stream to each connecting rod (other parts lubricated by oil spray) assuring complete and thorough lubrication at all times.

V-type design permits a shorter crankshaft and less height than with a "straight-in-line" engine, assuring a more compact power unit.

4-cycle single cylinder models, 3 to 9 hp., and 2-cylinder models, 7 to 13 hp., also available. Detailed data on request.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air Cooled Engines
MILWAUKEE 14, WISCONSIN

large area sprinklers
for lightweight pipe
for **Simplified Crop Irrigation**

Made in complete range from 1GPM and 5 lbs. pressure to 410 GPM and 100 lbs. pressure.

Taking water from nearby lakes, streams or well for large area irrigation is easier and more efficient with Skinner large area sprinklers. Connected to lightweight pipe with flexible couplings you get uniform coverage up to slightly less than 3 acres . . . pan test curves are available. Skinner Sprinkler features include: adjustment for controlling rotation, working parts easily accessible, no tool required when making adjustments, bronze, brass and stainless steel parts throughout. Write today for circular No. 449 for your files.

The SKINNER Irrigation Company
170 Canal St., Troy, Ohio

SKINNER—Pioneer and Leader in Irrigation for nearly half a century

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Bertran, Jose, R.—Plantation manager, Jose S. Bertran, Gral. Gomez, Camaguey, Cuba

Cheshire, C. A.—Extension agricultural engineer, Alberta Dept. of Agriculture, Edmonton, Alta. (Mail) 12007 127 St.

Carter, Thomas E.—Owner, Alvinston Motor Sales, Alvinston, Ontario, Canada

Christensen, Max C.—Student, Michigan State College, East Lansing, Mich. (Mail) 123 Mason Hall

Cloft, Harry F.—Graduate student, Michigan State College, East Lansing, Mich. (Mail) 126 Orchard

Cox, Thomas A.—Design engineer, J. I. Case Co., Burlington, Iowa. (Mail) 1819 S. Main St.

Cox, William T.—Graduate assistant, Alabama Extension Service. (Mail) P. O. Box 1643, Auburn, Ala.

Gibbs, Homer M.—Supervisor of agriculture department, Houston Lighting & Power Co., Box 1700, Houston 1, Tex.

Grommersch, James H.—Junior engineer, Dearborn Motors Corp., 15050 Woodward Ave., Detroit 3, Mich.

Haley, William A., III—Assistant to managing director, American Concrete Pipe Assn., 228 N. LaSalle St., Chicago, Ill.

Hall, Gladston H.—Instructor in veterans' vocational agriculture. (Mail) R R 2, Piedmont, Ala.

Hartsock, James G.—Instructor in agricultural engineering, Cornell University. (Mail) 314 Elmwood Ave., Ithaca, N. Y.

Huston, Willis E.—Instructor in agricultural engineering, University of Tennessee, Knoxville, Tenn.

Johnson, Charles R.—Product engineer, French & Hecht Division, Kelsey-Hayes Wheel Co., Davenport, Iowa

Jones, Joseph R.—Instructor in farm training. (Mail) R R 1, Box 140, Phenix City, Ala.

Kittridge, Charles W.—Farmer, R R 3, Dexter, Maine

Kloth, W.—Director, Forschungs-Anstalt fur Landwirtschaft Institut fur Landtechnische Grundlagenforschung, (20b) Braunschweig, Germany

Lawrence, Swanee B.—J. S. Lawrence & Sons, R R 2, Jackson, Tenn.

McConnell, Douglass W.—Vice-president, McConnell Sales & Engineering Corp., P. O. Box 5708, Homewood Branch, Birmingham 9, Ala.

Miller, Floyd O.—Irrigation engineer, Portland General Electric Co., 700 First St., Newberg, Ore.

Morris, Carlisle S.—Experimental lab., Allis-Chalmers Mfg. (Mail) 512½ Ohio St., LaPorte, Ind.

Newcomb, G. T.—Owner, G. T. Newcomb & Co., 401 Shoshone St., S., Twin Falls, Idaho

Newman, R. M.—Owner, R. M. Newman Mechanical Sales & Service, 486 Bob-O-Link Dr., Lexington, Ky.

Peckworth, Howard F.—Managing director, American Concrete Pipe Assn., 228 N. LaSalle St., Chicago, Ill.

Ratcliff, Russell Y.—Agricultural engineer, Northeast Louisiana Experiment Station, St. Joseph, La.

Rocklin, I. J.—President, Rocklin Mfg. Co., Sioux City, Iowa

Torazzi, Franco V.—Professional engineer, Fiat Co., Torino, Italy. (Mail) Corso Re Umberto 32

Trent, Warren C.—Associate agricultural engineer (research), Kansas State College, Manhattan, Kan.

Westerlund, Paul H.—Designer, John Deere Harvester Works. (Mail) 2741-11 Ave. "C", Moline, Ill.

Transfer of Grade

Benedict, Russell H.—Assistant professor of agricultural engineering, University of Arkansas, Fayetteville, Ark. (Junior Member to Member)

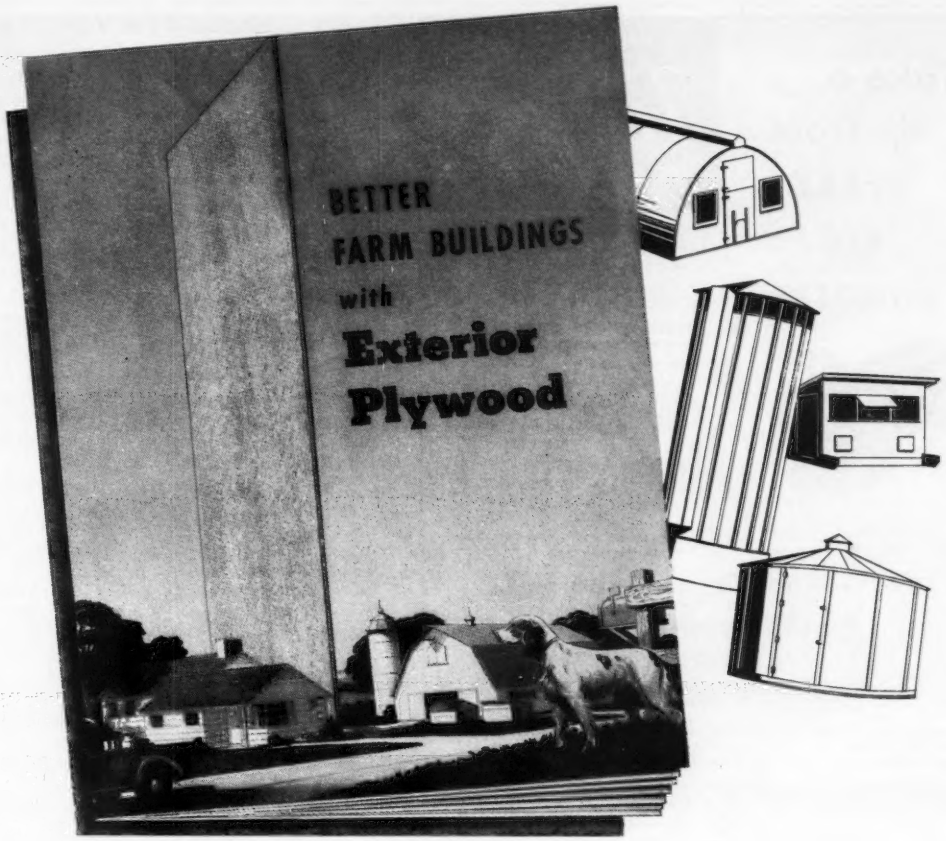
Colby, Halstead N., Sr.—Extension agricultural engineer, University of New Hampshire, Durham, N. H. (Junior Member to Member)

Engelbrecht, Howard H.—Climatologist, U. S. Weather Bureau, 557 Federal Office Bldg., San Francisco 2, Calif. (Junior Member to Member)

Johnson, E. M.—Regional manager, Remington Air Conditioning Div., Remington Corp. (Mail) 404 Vernon St., Media, Pa. (Junior Member to Member)

Johnson, Paul E.—Instructor in agricultural engineering, Purdue University, West Lafayette, Ind. (Associate to Member)

Savage, Charles T.—Sales promotion supervisor, International Harvester Co. (Mail) 4505 Chipoax Ave., Richmond, Va. (Junior Member to Member)



This Helpful 28-Page Booklet...

Free to Agricultural Engineers, Specialists

JUST OFF THE PRESS—twenty-eight pages of facts about Douglas fir plywood and its application to the farm field. Covered are such important subjects as: plywood grades and their uses, plywood application and finishing, home construction and interior and exterior remodeling with plywood, plywood for barns, grain bins, poultry houses, hog houses, silos, many other farm structures.

Agricultural engineers, extension specialists, county agents, and other farm leaders will find this information interesting and helpful. To such individuals, the booklet is available without cost. Just fill out the coupon below and mail it to your nearest Douglas Fir Plywood Association office.

Douglas Fir Plywood

Only Exterior-Type Douglas fir plywood—bonded with completely waterproof phenolic resin adhesive—should be used for farm service structures. The EXT-DFPA grade-trademark on the panel edge is your positive identification.

MAIL COUPON TODAY!

Send to office nearest you: Tacoma Bldg., Tacoma 2, Wash.; 848 Daily News Bldg., Chicago 6; 1232 Shoreham Bldg., Washington 5, D.C.; 500 Fifth Avenue, New York City 18.

DOUGLAS FIR PLYWOOD ASSOCIATION (Good in USA only)
Please send me a copy of "Better Farm Buildings with Exterior Plywood."

Name.....

Title.....

Address.....

City.....*Zone*....*State*.....

AE

SPRAYING SYSTEMS

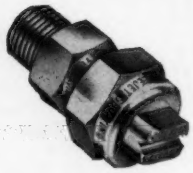
Take a tip from SPRAY RIG BUILDERS

TeeJet SPRAY NOZZLES

Leading manufacturers of spray rigs and sprayers like to demonstrate with TEEJET NOZZLES because:

- TeeJet uniform spray gives effective coverage with minimum driftage.
- "Lap-edge" spray pattern gives even distribution.
- Orifice tips are interchangeable.

Rigs may be quickly converted from one type of spraying to another.



For dependable, profitable spray nozzle sales, stock and sell the TEEJET line. Write for information . . . ask for Bulletin 55.

LINE STRAINER . . . Type ¾ Q

For spray rigs of any type, to be connected in line between pump and spray boom. For pressures up to 600 PSI. Provides 10 sq. in. of gross screen area. Write for Data Sheet 4658.

SPRAYING SYSTEMS CO. 3226 RANDOLPH STREET BELLWOOD, ILLINOIS (Suburb of Chicago)

Cylinders...

HYDRAULIC, HIGH OR LOW PRESSURE AND AIR CYLINDERS

For All Industrial Applications

Hydro-Line high pressure cylinders. Double acting — 1½" to 8" bore. Capacity 1500 P.S.I. Low pressure cylinders — 1½" to 12" bore, up to 750 P.S.I.

Standard air cylinders from 1½" to 14" bore. All hydraulic and air cylinders available in conventional mounting types.

Special hydraulic or air cylinders to meet your individual requirements.

FREE DATA

Write for additional information specifying hydraulic or air cylinders. ask for Bulletin AG 550.

Hydro-Line

HYDRO-LINE MANUFACTURING CO. • 718 19TH ST., ROCKFORD, ILL.

Standard for V-Belt Drives

(Continued from page 237)

is an appreciable radius at the top of the groove. The groove-width specification is misleading if it is a fictitious width obtained by extending the groove sidewalls in an imaginary straight line to the extreme outside diameter. The correct belt size which is required is determined by an effective outside diameter, which is that diameter where the groove width is as specified for the standard sheave grooves. The standards depict relationship between the effective outside diameters and over-all outside diameters for various types of sheaves and pulleys.

The standards describe various methods, employing the effective outside diameters, for determining the belt lengths for drives which are being designed. Each of these methods determines the effective length of an ideal belt under operating tension. The effective length of a V-belt is defined as being a function of the position where the belt rides in the sheave groove as well as of the actual length of the belt. The references to belt length throughout the standards, in the length tables, in the measuring or inspection procedure and in the methods for determining length from the drive layout, are consistently in terms of the effective length.

The standards specify the total adjustment range which should be designed into the drive to allow for installation of the belt and for take-up during its life. The installation allowance provides for (1) the negative manufacturing tolerance on the belt length, (2) the allowance for normal shrinkage, (3) the belt thickness, and (4) for the difference between the belt length in repose before it is installed and its length under tension after installation.

The take-up allowance provides for (1) the positive manufacturing tolerance on the belt length and (2) for the growth in its effective length during its life due to stretch and due to the side wear of the belt and sheaves.

The standards contain a table of minimum diameters for idler pulleys and sheaves with the caution that these should be absolute minima and that larger diameters will mean longer life for the bearings, sheaves and belts.

An appendix to the standards will give several typical form drawings for the suggested guidance of agricultural engineers and draftsmen. One form provides for typical inspection information for a belt. Others depict two and several sheave drives showing, along with other details, the sheave locations and dimensions, and the minimum position, maximum position, and approximate initial running position of the take-up sheave or pulley.

The purpose of the typical form drawings is to indicate the exact data with respect to belt size, fit, inspection and operation, which will make for efficient dealings between the farm equipment manufacturer and his belt suppliers. Also, perhaps it is not too presumptuous to anticipate that these form drawings can help coordinate the related responsibilities of the various divisions and departments within the organization of the farm equipment manufacturer.

If belt drawings are guided by the typical forms, and the other parts of the standards are observed, it should not be necessary for the farm equipment manufacturers to make repeated checks on the actual drive of many samples from different belt suppliers. After the first verification of the belt size on the drive and of the inspection requirements on the measuring machine, then the size of subsequent sample or production belts need only be verified on the measuring fixture.

Also, application of the standards and the suggested form drawings should preclude the necessity of showing on the belt blueprint different dimensions for belts of each manufacturer.

In conclusion, my comments will have missed the mark if they have seemed to emphasize unduly the advantages of the standards to the belt makers. The purpose of the standards is to reduce costs. In the long run, the cost of supplying any product must be recovered by the supplier. On the other hand, the competition in the belt industry insures that any savings are passed on to its customers. The individual companies of the V-belt industry cooperate technically to formulate these standards and then stand to gain only to the extent that the standards promote the use of their products. We can only help ourselves by helping the manufacturers and users of farm equipment. We believe that these standards will help them.

Saturday Night Is the BIGGEST NIGHT of the Week!

On Saturday night, the chores are finished a little earlier . . . second helpings go begging at the supper table . . . friendly yard lights wink out like sleepy stars as byroads and highways funnel farm families into main street until stores and sidewalks overflow.

The menfolk gather on street corners to speculate on the weather, to brag about their livestock, to swap experiences and trade advice. Farm women track down bargains, and talk over news that will be printed in the next edition of the Weekly Herald. Youngsters splurge their allowances at popcorn stands and ice cream parlors.

Folks use shopping as an excuse for coming to town, but the thing they really look forward to on Saturday night is the community reunion. They delight in meeting old friends and making new ones. They enjoy trading with storekeepers who know their needs as well as their names.

Saturday night in small-town America—with its friendliness, and neighborly helpfulness—is a breath of warmth in a cold, cynical world. No wonder a walk down Main Street renews one's faith in America and rekindles the hope that we may yet use this Saturday night spirit to bring peace and plenty to mankind.

JOHN DEERE

JOHN DEERE QUALITY FARM EQUIPMENT

MOLINE • ILLINOIS

Specify...

TUTHILL

MODEL 5-W

The Pump for Your Weed and Pest Control Equipment

No other pump for tractor spraying outfits combines these practical advantages of the Tuthill Model 5-W in one compact unit:

- **Direct-mounted on power take-off.**
- **Adaptable to pulley drive.**
- **Compact . . . close-coupled design. Over-all dimensions . . . 4½" x 5½" x 6⅜" . . . Net weight 12½ lbs.**
- **Fits 1⅛" or 1⅜" spline shafts.**
- **Pressure range from 0 to 150 pounds per square inch.**
- **Delivers 5 g.p.m. at 100 p.s.i. at 550 r.p.m.; 16 g.p.m. at 100 p.s.i. at 1750 r.p.m.**
- **Built of highly corrosion-resistant materials to handle a wide variety of spray liquids.**
- **Self-priming . . . self-lubricating.**

Write for complete details.

TUTHILL PUMP COMPANY

939 East 95th Street . Chicago 19, Illinois . Phone RE 4-7420

SALES ENGINEER WANTED

Large manufacturer of hydraulic equipment selling primarily to tractor manufacturers is seeking an experienced Sales Engineer. Position requires complete knowledge of agricultural market. Engineering background desired. Prefer man in middle thirties. Must be able to travel. Please give full details of experience, education, salary desired and enclose recent snapshot. Inquiry will be held in strictest confidence. Reply Pacific Division, Bendix Aviation Corp., 11600 Sherman Way, North Hollywood, Calif.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated:

POSITIONS OPEN: (1949): MAY—O-688.. AUGUST—O-34-675, 34-678. SEPTEMBER—O-84-682. NOVEMBER—O-127-690. (1950): JANUARY—O-189-692, 201-697. MARCH—O-262-700, 262-701, 253-703, 270-705. APRIL—O-284-707, 281-708, 282-709, 297-710, 297-711, 306-712.

POSITIONS WANTED: (1949): APRIL—W-248. MAY—W-258-271. JULY—W-288, 299. SEPTEMBER—W-67-312. OCTOBER—W-111-316. DECEMBER—W-145-323, 146-324, 151-325, 137-327, 157-328. (1950): JANUARY—W-164-331, 175-334, 179-335, 171-336, 177-337, 190-338. FEBRUARY—W-203-340, 199-342, 214-343, 208-344, 218-345, 213-349. MARCH—W-227-351, 247-352, 228-353, 256-355, 248-357, 252-358, 257-359, 246-360, 268-361, 258-362. APRIL—W-289-363, 263-364, 283-365, 296-366, 255-367, 294-368, 299-369, 304-370, 249-372, 291-373, 293-374, 307-375.

NEW POSITIONS OPEN

POWER USE COORDINATOR to organize and supervise rural electric educational program for a state rural electric cooperative association in the Midwest. BS deg in agricultural engineering, or equivalent. Special training desirable in phases of electrical engineering pertinent to rural electrification. Some experience in agricultural engineering field desirable. Good personality and good health required. Man selected will head department. Advancement determined by ability and initiative. Age 25-40. Salary $3600-5400. O-286-713

FARM BUILDING CONSULTANT and sales representative, to work with farmers on building requirements and to sell lumber and prefabricated farm buildings, with progressive dealer and fabricator in a rural community in Nebraska. Training and experience in agricultural or architectural engineering desired. Work requires pleasing personality and ability to meet people. Possibility of branching out in several fields. Company furnishes car. Age 25-30. Salary $200 mo, with bonus setup, depending on results. O-308-714

FIELD ENGINEER for promotional development work with national trade association in farm building materials field. Location Illinois. BS deg in agriculture or agricultural engineering. Usual personal qualifications for promotion work. Farm background and experience in extension work, agricultural sales, or promotion desirable. Must be willing to travel. Opportunity for advancement good. Salary $3000 - 4000, plus expenses. O-329-715

FARM STRUCTURES engineers (3) for sales promotion work with manufacturer of farm building material. Will require contacts with agricultural and engineering colleges, farm leaders, dealers, and jobbers; also helping train field representatives. Locations open are Atlanta, Ga.; Chicago, Ill.; and New York, N. Y. BS deg or higher in agricultural engineering, or equivalent. Want men with 5 yr or more experience in supervisory or administrative work in agricultural engineering; and 5 yr or more in sales promotion, direct selling, or advertising. Must have initiative and ability to work with minimum supervision in effective handling of contacts in both technical and sales fields. Opportunity for advancement up to individual. Age 30-45. Salary $300-500 mo. O-342-716

NEW POSITIONS WANTED

DESIGN, development, sales or service in power and machinery or soil and water field, in federal service or with manufacturer or distributor. BS deg in agriculture, June, University of Maine. Farm work on potato production. One summer as soil conservation aide. War service in Army Air Corps nearly 2 yr. Aviation cadet studying to be flight engineer at time of discharge in 1945. Single. Age 24. No disability. Available June 20. Salary open. W-320-376

DEVELOPMENT, extension, or teaching in rural electric or soil and water field, in public service or private industry, anywhere in U.S.A. BS deg in agricultural engineering, May, Oklahoma A & M College. Farm background. Summer work with a farm implement dealer, on assembly, repair, and operation of farm machinery. One semester part time work in rural electrification laboratory. One semester part time work as plumber's helper. War service in Navy, 27 mo. Married. Age 23. No disability. Available June 1. Salary open. W-327-377

EXTENSION, teaching, research, development or management, in soil and water or power and machinery field, in public service or private industry, anywhere in U.S.A. BS deg in agricultural engineering 1948, University of Tennessee. Experience as dairy herd improvement supervisor, Tennessee dairy extension department, 1942-43. Assistant production foreman, Tennessee Eastman Corp. 1944-45. Veteran's agricultural instructor, 1948 to present. War service one year in U. S. Navy. Married. Age 27. No disability. Available July 1. Salary $3600-4000. W-328-378

(Continued on page 256)

Curved Lines

The Shortest Distance to More Profitable Farming

Straight furrows, accurately checked corn, and even rows have ever been the marks of a good farmer — a source of pride and satisfaction.

But, in most cases it wasn't good farming. On rolling land these furrows up and down the slopes become gutters that speed rainfall, carrying off in hours, precious topsoil that took Nature hundreds of years to build.

When the top soil is gone, the land is gone... the source of all new wealth is gone.

Contour farming that keeps furrows level around the slopes —saves moisture, raises the water table, assures greater crops in dry years, keeps the land from gullying and eroding.

But conservation goes deeper than simply contouring. It is using land to best advantage. This means putting to grass and pasture some land that is now in cultivated crops. It may mean planting to field crops good land that may now be in woodlots, using marginal land for trees and forest. It is building dams, slowing down streams, changing many of our methods of land management.

This looks both to the future and the present. It means a permanent agriculture for our children and our children's children. It means a more profitable agriculture... bigger yields, easier labor, greater profits for ourselves.

Saving our land is a job for all... for those of us who make farm machinery... for you who advise farmers... for those who actually farm and till the soil.

THE MASSEY-HARRIS COMPANY
Quality Avenue, Racine, Wisconsin

Manufacturers of tractors, combines, corn pickers, forage harvesters, and a full line of quality farm machinery for more than a hundred years.

MASSEY M-H HARRIS TRACTORS / COMBINES / IMPLEMENTS

Make it a Massey-Harris

For a GREATER YIELD—EARLIER
McDowell
COUPLINGS and FITTINGS
Use a McDowell equipped sprinkler system to harvest your crops ahead of your neighbors for the profitable "early" market. McDowell system gives you better crops with less work.
WRITE FOR FREE BOOKLET
• Rapid assembly without tools
• Easily moved and reassembled
• One-man operation
McDOWELL
McDOWELL MANUFACTURING COMPANY
PITTSBURGH 9, PENNA.

PRODUCT DESIGN ENGINEER

Rapidly expanding farm equipment manufacturer has an opening for a top notch Product Design Engineer

Farm Implement or
Related Design Experience Required

Engineering Offices Located in
Southeastern Wisconsin

Top Wages
Excellent Pension Plan
Paid Life, Health and Accident Insurance

Write FEM in care of AGRICULTURAL ENGINEERING giving full particulars in your letter.

PERSONNEL SERVICE BULLETIN

(Continued from page 254)

DEVELOPMENT, research, extension, sales, or service in power and machinery, rural electric or soil and water field, with experiment station, manufacturer, or distributor, in northern or western U.S.A., or possibly foreign location. Interested in opportunity for outdoor work. BS deg in agricultural engineering, June, South Dakota State College. Farm background. War noncommissioned service in Army Corps of Engineers, 2 yr. Since then while in school built and sold one house, and operated an irrigated farm. Married. Age 25. No disability except vision, corrected with glasses. Available June 5. Salary open. W-312-379

SALES or service work in rural electrification with public utility in North Central area. Willing to travel. BS deg in agricultural engineering, June, Purdue University. Extra courses in electrical engineering, on power distribution and electrical wiring and contracting. Farm background. Farm construction and modernization work at home, 3½ summers. Army enlisted service 14 mo. Single. Age 23. No disability. Available June 21. Salary Open. W-333-380

TEACHING, sales, or service in power and machinery field with college or distributor, anywhere in U.S.A. BS deg in agricultural engineering, June, University of Massachusetts. Experience in farm work, dairying, machine shop, truck driving, lumber, sawmills, surveying and pantograph operation. Single. Age 32. No disability. Available June 15. Salary $3500. W-325-381

EXTENSION, teaching, or research in power and machinery, rural electric, or soil and water field, in public service, in South or Northeast. BS deg in agriculture, University of Connecticut. Dairy and poultry farm background, 15 yr. Electric arc and oxy-acetylene welder, 2 yr. War noncommissioned service in Army Air Corps, 3 yr. Single. Age 27. No disability. Available August 1. Salary $3100 min. W-326-382

DESIGN, development, research, sales, or service, in power and machinery or product processing field, with manufacturer, processor, distributor, or consultant, anywhere in U.S.A. BS deg in agricultural engineering, June, University of Minnesota. Graduating in upper 10 per cent of class. Midwest diversified farm background. Construction work with pipe line contractor, 6 mo. Servicing and demonstrating farm machinery with distributor, 4 mo. War noncommissioned service 22 mo with parachute infantry. Single. Age 24. No disability. Available June 15. Salary open. W-338-383

EXTENSION, research, sales, or service in power and machinery or soil and water field, in public service or private industry, preferably in Tennessee, Kentucky, Mississippi or nearby areas. Willing to do some traveling. BS deg in agriculture, major in agricultural engineering. Farm background. Representative for tobacco company one year. Currently nursery and greenhouse inspector with Tennessee State Department of Agriculture. Married. Age 28. No disability. Available now. Salary $275 mo. W-339-384

DEVELOPMENT, management or research in farm structures, irrigation, drainage, or field testing power and machinery, with manufacturer, processor, or consultant in any location suitable for travel with wife. BS deg in agricultural engineering, 1949, University of Missouri. With U. S. Soil Conservation Service 2 yr; currently as assistant drainage specialist. War service in Army Air Corps, nearly 2 yr. Married. Age 23. No disability. Available on 2 mo notice. Salary open. W-349-385

DESIGN, development, research, sales, or service, in power and machinery or soil and water field, with federal agency, manufacturer, distributor, or farming operation, anywhere in U.S.A. Open to consideration for foreign locations. Willing to do some traveling. BS deg in agriculture, June, University of Maine. Farm background, including maintenance and repair of farm machinery. Single. Age 23. No disability. Available June 26. Salary $2800. W-351-386

DESIGN, development, or research in power and machinery or rural electrification, with public service or private industry, in West, Southwest, or South America. BS deg in mechanical engineering, June, New Mexico A and M College. Farm background. Student assistant in ME department 2½ yr. Draftsman for farm machinery designer and builder 3 mo during College. War enlisted service in Army, 21 mo, mostly in A S T R P. Single. Age 22. No disability. Available June 10. Salary $3000. W-341-387

SALES or writing in power and machinery field with manufacturer, preferably in eastern U. S. Will travel in U. S. if desired. BS deg in agricultural engineering, June, Pennsylvania State College. Farm background. Managed home farm one summer. General work experience in manufacturing plant one summer. Work in commercial flower gardens one summer. Numerous extracurricular activities while in school. War enlisted service in Navy, 2 yr. Single. Age 24. No disability. Available June 15. Salary open. W-347-388

New Bulletins

Cost of Operating Farm Machinery (Eastern Canada), by W. Kalbfleisch. Publication 750, Farmers Bulletin 118. March 1950 revision of previous publication of the Canadian Department of Agriculture, Experimental Farms Service (Ottawa). This 36-page bulletin presents a condensed picture of ownership and operating costs for various types, sizes, and models of farm operating equipment commonly used in eastern Canada. An introduction explains the method of computing costs and factors used in calculating costs, as well as directions for using tables. This information will make the bulletin valuable to anyone considering or making similar studies in other areas. Nine condensed tables cover specifically method of calculating machine costs, estimated cost of operating machines, method of calculating tractor costs, estimated costs of operating farm tractors, motor trucks, electric motors, and gas engines, method of calculating horse labor costs, estimating cost of farm operations (eastern Canada), and power machinery and equipment inventory and annual operating costs on 50, 100 and 200-acre farms.